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RRS *James Clark Ross* Cruise 193

29 NOV-08 DEC 2007

Drake Passage repeat hydrography: WOCE Southern
Repeat section 1b – Burdwood Bank to Elephant Island

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ABSTRACT <p>A repeat hydrographic section (WOCE section SR1b) across Drake Passage was occupied during November and December 2007 aboard the RRS <i>James Clark Ross</i> (JR193). This is a section across the Antarctic Circumpolar Current at its narrowest point, with the primary objective of this cruise being to determine the currents, characteristics and transports of the various water masses.</p> <p>A total of 42 CTD/LADCP stations were sampled across Drake Passage and down to Rothera, of which 30 comprised the SR1b repeat hydrographic section between Burdwood Bank and Elephant Island. In addition to temperature, salinity and oxygen profiles from the sensors on the CTD package, water samples from the 24-bottle rosette were analysed for salinity at each station, in order to calibrate the CTD salinity profiles. In addition, samples were collected from the ship's underway system to calibrate and complement the data continually collected by the OceanLogger. Full depth velocity measurements were made at every station by an LADCP (lowered acoustic Doppler current profiler) mounted on the frame of the rosette. Throughout the cruise, velocity data in the upper few hundred metres of the water column were collected by the ship's VMADCP (vessel mounted acoustic Doppler current profiler) mounted on the hull. Meteorological variables were monitored using the onboard surface water and meteorological sampling system. Bathymetry data were also collected using a Simrad EA600 echo-sounder, and a number of ARGO floats and a surface drifter deployed.</p> <p>The work is a component of the "Sustained Observations" supported by NERC's Oceans 2025 programme. This report describes the methods used to acquire and process the data on board the ship during cruise JR193.</p>	
KEYWORDS ADCP, Antarctic Circumpolar Current (ACC), ARGO, CTD, Drake Passage, LADCP, Marguerite Trough, Thermosalinograph, WOCE repeat line SR1b	
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Overview

This expedition, from Port Stanley (29th November 2007) to Rothera (8th December 2007) carried out 4 separate science projects. Two of these involved repeats of previous CTD sections for the purpose of long-term monitoring, and used the same techniques and same personnel, and are consequently detailed together here; the other work done on this voyage was the deployment of 2 POL landers (with bottom pressure recorders) and a short sortie to a disused base at Damoy to make it safe (these are only mentioned in this account in passing).

Objectives

The repeat section SR1b across Drake Passage has been occupied 12 times before by NOC/BAS. The section runs from Burdwood Bank, a shallow rise to the south of the Falkland Islands, to Elephant Island at the eastern end of the South Shetland Islands. Drake Passage is the narrowest passage through which the Antarctic Circumpolar Current (ACC) must flow, and this is a convenient "choke point" for making measurements over the entire ACC. The timing and staging of this cruise makes use of the need for BAS to replenish its station at Rothera at this time of year. Consequently all such transects have been early in the austral summer. The objective of this section is thus not to monitor variations on the seasonal time scale or shorter, which may be done with judicious mooring deployments, but to look at changes on the interannual to decadal scales.

The key objectives for the CTD section across Drake Passage are:

- (i) to determine the interannual variability of the position, structure and transport of the Antarctic Circumpolar Current (ACC) in Drake Passage;
- (ii) to examine the fronts associated with the ACC, and to determine their positions and strengths;
- (iii) by comparing geostrophic velocities with those measured directly (by the lowered ADCP), to determine the size of ageostrophic motions, and to attempt to estimate the barotropic components;
- (iv) to examine the temperature and salinity structure of the water flowing through Drake Passage, and to identify thereby the significant water masses;
- (v) to calculate the total flux of water through Drake Passage by combining all available measurements.

To the southwest of Rothera lies the Marguerite Trough, which has been surveyed on two previous cruises. The section spans ~52 km, with depths extending to almost 1000m. The region is important as it provides a potential pathway for warm deep water to flow onto the shelf, where it could impact sea ice formation and extent. The CTDs will be used to identify the core of the warm water within the trough, and characterise its temperature structure. As part of BAS LTMS (Long-Term Monitoring and Survey), this line of CTDs will be repeated at least annually, building up a time series of deep-water temperature in this location.

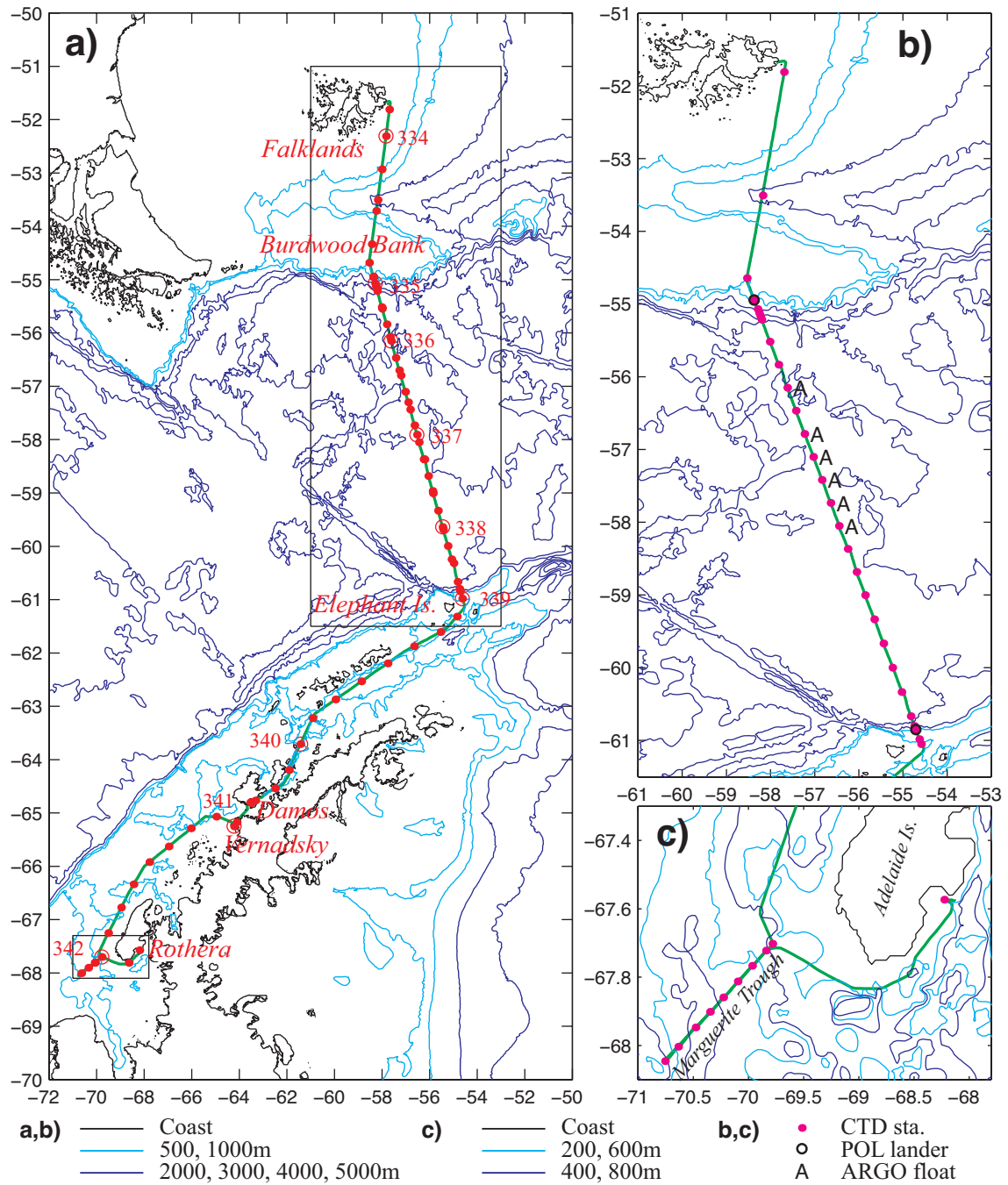


Figure 1: Track of RRS *James Clark Ross* during cruises JR193 and JR171. Red dots show progress every 3 hours, and red circles and numbers indicate start of each day. b) CTD stations and other deployments as part of JR193. c) CTD stations during JR171. Contoured bathymetry is from Smith & Sandwell.

Cruise Narrative

The science party, technical support and people destined for Rothera travelled south on the RAF flight leaving Brize Norton on Tuesday 20th November, reaching Mount Pleasant Airfield, Falkland Islands in the early afternoon of Wednesday 21st November, with the expectation of sailing on Friday 23rd November. A few hours after joining the ship, the master briefed us that the RRS *James Clark Ross* (JCR) had scraped against an underwater rock near Signy 4 days earlier, and advice was being sought on further action. As well as internal inspections of the inner hull, there were external inspections by divers, and a surveyor was requested from Lloyds. The recommendation made was that the vessel was presently seaworthy, but that ruptured joints should be temporarily encased in concrete to provide a seal and to prevent vibrations exacerbating the size of the tears. This work took place on Monday 26th November, with many willing volunteers for the chain of buckets to get the concrete to the affected area. Time was then required for the concrete to set and dry properly, before tanks on that side could be refilled. Consequently departure was not until the afternoon of Thursday 29th November.

The extended mobilization time was used to transfer instruments and Niskin bottles to the UKORS CTD frame (required because it can accommodate the upward- and downward-looking LADCP units), and to set up the LADCP control hardware in the UIC (Underway Instrument Control room). Shortly after departure from the berth at MIPASS there was a fire muster in Port William Sound, and then we had a trial CTD cast.

This provided an early opportunity to test that the firing mechanisms on the pylon worked, that the CTD instrumentation and calibration files were correctly enabled, and that there was no leakage from the bottles. It also provided a good occasion for practical training on cocking bottles and subsequently taking water samples. A deeper test station (>2000m) was performed 10 hours later in the gap between the Falkland Islands and Burdwood Bank. During all of this time the ship-mounted ADCP (75 kHz Ocean Surveyor, which has a range of up to 1000m) was in bottom-tracking mode; for the start of the CTD section proper it was switched to water-tracking mode, which enables a greater pinging rate.

This section began at 14:00 UTC on day of year 334 (30th November), with closely-spaced shallow (less than 1000m) CTDs that went smoothly because of the training earlier. In fact, the whole section proceeded very well, with the weather never precluding deployments. On a few occasions the currents were so strong that the vessel was allowed to move from its nominal station so as to keep the CTD cable from veering too much from the vertical.

There were two minor instrumental problems during this CTD/LADCP section. Firstly, there were problems with one of the LADCP units; this was initially the downward-looking one, but the two were interchanged after cast number 18 to ensure more reliable performance for the more important downward-looking site. Secondly, a curious artefact was noted in the data from the oxygen sensor when near the seabed, and its position on the CTD multiplexer was changed to remedy this problem.

The other interruptions to the regular routine of CTD operations were due to work with other scientific equipment. Two POL landers with bottom-pressure recorders were deployed after CTD stations 5 and 30, corresponding to around the 1000m isobaths on either side of Drake Passage. Time was required not just for deployment, but also to determine the final location

on the seabed using acoustics. There were also 6 ARGO floats from the Met Office and a surface drifter from SAMS deployed during this section. The section was completed at 01:30 on day of year 339, within sight of Elephant Island, Clarence Island and a number of icebergs. The route then went between these islands and along a channel to the south of Elephant Island, with a 30 km long iceberg lying further south. For this transit the swath system was turned on to provide breadth of seafloor mapping along a route not normally used. The air temperature was now noticeably colder, and there were occasions of reduced visibility due to light mist. The ship entered the Neumeyer Channel at 08:00 on day of year 340, with many people in thick insulation jackets on Monkey Island to savour the views. Damoy was reached at ~10:00, with a party of about a dozen visiting the site via boat. Their tasks were to board up the windows of the base, remove any combustibles or explosive material and reclaim two skidoos. Their tasks were completed in the ~4 hours allotted. (An earlier intention had been to dismantle the base entirely, but this plan had been rescinded prior to departure from the Falklands.) Also during this period the two people from POL serviced a tide gauge at Port Lockroy. Various cruise ships were seen during this time.

A few hours later we were approaching the Ukrainian base at Vernadsky. (This had been the UK base Faraday until 1997, when it was sold on.) The chief purpose of the call was for the POL people to service the tide gauge there, which is still looked after by PSMSL (Permanent Service for Mean Sea Level). However, others were keen to go ashore because of the Ukrainians' legendary hospitality. Communications with Vernadsky had been difficult prior to arrival, but were eventually established with the aid of Vsevolod Afanasyev speaking in Russian on the radiophone.

After the visit to Vernadsky, we exited the archipelago via French Channel and then turned south along the west coast of the Antarctic Peninsula, where we were more exposed to blustery conditions. The last scientific work was to be a short CTD section across Marguerite Trough just to the southwest of Adelaide Island. This section, corresponding to JR171, was run from the most offshore station inwards, and once again sea-state conditions gave no real problems, with the 9 CTD/LADCP stations (ranging from 300 to 950m depth) being completed in under 11 hours during day of year 341/342. We then sailed round the southern tip of Adelaide Island and past Jenny Island to reach the bay outside Rothera. Once at the bay, we performed a final CTD at the site of the Rothera Time Series (RaTS) station. The same site had been occupied the day before by Rothera personnel using their hand-deployed system, so the repeat provides a vicarious calibration of their CTD system. Water samples were taken from 12 depths for oxygen isotope analysis. After this, the underway-pumped supply was finally turned off (17:40 on day of year 342).

We berthed at Bisocoe Wharf, Rothera at 19:30 GMT on day of year 342, having a little earlier seen the Dash-7 come in to land. The scientific party remained on the ship for 4 further nights, enabling us to finish analysing most crates of salts, process and archive data and work on the cruise report. We were also able to provide some manpower for the unloading of the ship. RRS *James Clark Ross* left for its next cruise on day of year 346, and we flew out of Rothera just after breakfast that morning. The flight was uneventful, with clouds usually obscuring the view. We landed at the civil airport after ~5.5 hours. We then spent 3 nights at the Upland Goose Hotel before joining the return RAF flight from Mount Pleasant to Brize Norton. A final delay of 2 hours was caused by the 'Arrivals Desk' at Brize Norton not being prepared for non-EU citizens.

Graham Quartly & Hugh Venables

1. CTD Systems Operation

1.1. Introduction

A Conductivity-Temperature-Depth (CTD) unit was used on JR193 to produce vertical profiles of the temperature and salinity of the water column. Thirty-two stations were occupied across the Drake Passage SR1b transect, nine in Marguerite Trough and one in front of Rothera Base giving 42 casts in total. The nominal station locations across Drake Passage are listed in Table 1 and actual locations at the start and at the end of each cast, alongside the water depth, are listed in Table 2. Station 1 was a shallow bottle test station allowing us to test new bottles that had been mounted onto NOC's CTD frame and also the software instrument configuration. A deep test station (#2) was chosen to check all the instruments and data processing methods before performing the Drake Passage repeat section.

Table 1: Nominal station positions for Drake Passage section (Bacon et al., 2003)

Station	Lat (°S)	Lat (min)	Long (°W)	Long (min)
1	54	40.00	58	32.61
2	54	55.34	58	23.10
3	54	56.62	58	22.31
4	54	57.66	58	21.67
5	55	04.18	58	17.62
6	55	07.27	58	15.71
7	55	10.25	58	13.86
8	55	12.86	58	12.24
9	55	31.00	58	01.00
10	55	50.00	57	49.23
11	56	09.00	57	37.45
12	56	28.00	57	25.67
13	56	47.00	57	13.90
14	57	06.00	57	02.12
15	57	25.00	56	50.35
16	57	44.00	56	38.57
17	58	03.00	56	26.79
18	58	22.00	56	15.02
19	58	41.00	56	03.24
20	59	00.00	55	51.47
21	59	20.00	55	39.07
22	59	40.00	55	26.67
23	60	00.00	55	14.28
24	60	20.00	55	01.88
25	60	40.00	54	49.49
26	60	47.97	54	44.55
27	60	49.99	54	43.30
28	60	51.02	54	42.66
29	60	58.86	54	37.80
30	61	03.00	54	35.23

Table 2: CTD Stations during JR193 (stations 1-32) and JR171 (stations 33-42). The two times and positions given for each station represent variables for the start and end of the station. Depth (m) is the depth derived from the maximum CTD depth plus the altimeter height off the seabed.

Station	Julian Day	Time hhmmss	Latitude °S	Latitude (mins)	Longitude °W	Longitude (mins)	Water depth (m)	CTD Max pressure (db)
193ctd01	333	21:03:05 21:24:36	51 51	48.6600 48.6131	57 57	41.6500 41.6370	98.8	80
193ctd02	334	06:08:22 07:46:15	53 53	30.3800 30.4000	58 58	10.9700 11.000	2319.4	2342.1
193ctd03	334	14:06:00 14:36:00	54 54	40.000 40.000	58 58	32.6100 32.6100	394.2	386.6
193ctd04	334	16:35:10 17:05:24	54 54	55.3378 55.3400	58 58	23.1000 23.1000	523.0	517.3
193ctd05	334	17:49:36 18:43:20	54 54	56.6300 56.6200	58 58	22.3090 22.3100	1150.3	1153.3
193ctd06	334	20:36:53 21:47:00	54 54	57.6900 57.6648	58 58	21.6755 21.6779	1597.3	1609.2
193ctd07	334	22:49:55 00:20:30	55 55	04.2245 04.2100	58 58	17.6500 17.6400	2071.0	2092.0
193ctd08	335	01:46:35 03:28:00	55 55	07.2700 07.2635	58 58	15.7000 15.7000	2515.9	2539.7
193ctd09	335	04:27:56 06:26:18	55 55	10.2400 10.2400	58 58	13.8600 13.8500	2996.4	3034.7
193ctd10	335	07:12:28 09:42:58	55 55	12.8600 12.8600	58 58	12.2400 12.2500	3912.4	3976.2
193ctd11	335	11:48:20 14:37:10	55 55	30.9928 31.0300	58 58	00.9900 00.8139	4217.6	4238.0
193ctd12	335	16:42:35 19:42:37	55 55	50.0100 50.6045	57 57	49.2100 47.0468	4755.9	4842.4
193ctd13	335	21:39:21 23:52:10	56 56	09.0100 09.0100	57 57	37.3700 37.3800	3377.6	3424.5
193ctd14	336	02:05:47 04:35:36	56 56	28.0206 28.0000	57 57	25.6726 25.6600	3878.6	3942.4
193ctd15	336	06:53:09 08:54:44	56 56	47.0100 47.6300	57 57	13.8800 12.6500	3218.1	3262.6
193ctd16	336	11:09:03 13:40:00	57 57	06.0000 06.4800	57 57	02.1200 01.1400	3866.1	3928.2
193ctd17	336	15:51:34 18:16:32	57 57	25.0000 26.2500	56 56	50.3200 49.0100	3834.3	3895.7
193ctd18	336	20:24:24 22:31:16	57 57	43.9700 43.9738	56 56	38.4300 38.4600	3490.8	3543.5
193ctd19	337	01:06:11 03:33:23	58 58	02.9500 02.8700	56 56	26.9800 27.4000	3975.3	4040.5
193ctd20	337	06:08:56 08:38:03	58 58	21.9200 21.4300	56 56	15.0000 15.2400	3895.3	3959.8
193ctd21	337	11:02:27 13:18:30	58 58	40.9900 40.9900	56 56	03.2400 03.2400	3754.1	3812.2
193ctd22	337	15:28:15 17:43:59	59 59	00.0500 00.0000	55 55	51.5200 51.4700	3774.6	3832.6
193ctd23	337	20:00:25 22:14:04	59 59	20.0100 20.0100	55 55	38.9800 38.9800	3755.2	3811.0
193ctd24	338	00:22:20 02:38:02	59 60	40.0000 00.0000	55 55	26.6800 14.2800	3674.2	3733.3
193ctd25	338	05:07:50 07:18:20	59 59	59.9300 59.3600	55 55	14.2700 14.5400	3501.8	3555.2

193ctd26	338	09:50:36 11:52:15	60 60	19.9600 18.9500	55 54	01.8000 59.8100	3413.5	3463.7
193ctd27	338	14:21:03 16:14:13	60 60	40.0100 40.0100	54 54	49.5149 49.5200	3093.3	3133.2
193ctd28	338	17:22:10 18:56:30	60 60	48.0100 47.9700	54 54	44.5700 44.5600	2578.8	2610.7
193ctd29	338	19:31:37 20:38:29	60 60	49.9800 49.9800	54 54	43.2600 43.2600	1739.9	1753.2
193ctd30	338	21:10:22 21:54:20	60 60	51.0100 51.0100	54 54	42.6508 42.6400	1028.1	1030.3
193ctd31	338	23:29:50 23:59:30	60 60	58.8800 58.8640	54 54	37.9100 37.8000	580.7	580.1
193ctd32	339	00:37:37 01:01:37	61 61	03.0000 03.0000	54 54	35.3000 35.2290	357.1	352.7
193ctd33	341	23:51:57 00:12:50	67 67	42.1300 42.1300	69 69	46.9200 46.9200	294.5	288.8
193ctd34	342	00:44:43 01:12:02	67 67	43.3500 43.3600	69 69	50.4400 50.4500	475.6	472.1
193ctd35	342	01:57:29 02:34:52	67 67	45.9900 46.0300	69 69	58.0000 57.9700	706.6	707.6
193ctd36	342	03:13:00 03:46:37	67 67	48.7500 48.7560	70 70	05.8200 05.7180	601.8	595.6
193ctd37	342	04:26:09 04:59:20	67 67	51.5400 51.5500	70 70	13.6510 13.6700	632.6	631.4
193ctd38	342	05:36:00 06:16:11	67 67	54.0700 54.0700	70 70	28.8600 20.8600	941.2	943.2
193ctd39	342	06:55:00 07:31:26	67 67	56.8300 56.8800	70 70	28.7000 28.7300	851.2	850.8
193ctd40	342	08:23:33 08:55:39	68 68	00.2000 00.2008	70 70	38.1400 38.1432	699.1	696.4
193ctd41	342	09:50:56 10:05:17	68 68	02.7500 13.7600	70 69	45.3900 00.3800	170.2	162.7
193ctd42	342	17:06:00 17:39:20	67 67	34.4000 34.4012	68 68	13.5200 13.5257	507.1	504.0

1.2. Configuration

A full-sized SBE 24 carousel water sampler, holding 12 bottles, connected to an SBE 9 plus CTD and an SBE 11 plus deck unit were used to collect vertical profiles of the water column. The deck unit provides power, real-time data acquisition and control. The underwater SBE 9 plus unit featured dual temperature and conductivity (SBE 4) sensors, and a Paroscientific pressure sensor. A T-C (temperature-conductivity) duct and a pump-controlled flow system ensure that the flow through the T-C duct is constant to minimize salinity spiking. Files containing the data are saved in binary and ASCII format.

In addition, an altimeter, a fluorometer, an oxygen sensor and a PAR/Irradiance sensor were attached to the carousel. The altimeter gave real-time accurate measurements of height off the seabed once the instrument package was within approximately 100 m of the bottom. The Simrad EA600 system would sometimes lose the bottom or give erroneous readings on station, so care was needed to interpret these digitised records. Readings from oxygen sensor SBE 43 showed a 6-second delay relative to the pressure sensor due to the water transit time through the instrument.

For all stations, two UKORS LADCPs (one upward-looking, the other downward-looking) were attached to the main CTD frame and a fin was also added to the frame to reduce rotation of the package underwater.

1.3. Deployment

The CTD package was mounted on NOC's frame and deployed from the mid-ships gantry, on a single conductor torque-balanced cable connected to the CTD through the BAS conducting swivel. This CTD cable was made by Rochester Cables and was hauled on the 10T traction winch. The new winch cable, of the same construction as previous one, was used through the whole cruise and it worked very well. The general procedure was to start data logging, deploy, and then to stop the CTD at 10m cable out. The pumps are water activated and should come on 60 seconds after the CTD is in the water. If the word display on the Deck Unit is set to 'E' then the least significant digit on the display indicates whether the pumps are off (0) or on (1). After a 2-5 minute soak, the package was raised to just below the surface and then continuously lowered to a nominal 10m above the seabed.

We had mounted 12 Niskin bottles on the CTD frame. At each station the first bottle was fired at the bottom of the downcast and subsequent Niskin bottles were fired during the upcast, with a pause of 5 seconds between the winch stopping and the bottle firing. The detailed procedure for CTD casts used during this cruise is given in Appendix 1. At most of the stations 12 bottles were fired but not all of them were sampled. On average we had 9 samples per cast as only salinity analysis was performed. At stations 31 and 32, only 10 and 8 bottles were fired respectively while at Station 1 we fired all 24 bottles. For the last CTD station (#42) we also took samples for $\delta^{18}\text{O}$ isotope analysis. Salinity sample collection and analysis is discussed in sections 2.6 and 3.

1.4. Data acquisition

The CTD data were logged via the deck unit to a 1.4 GHz P4 PC, running *Seasave Win32 version 5.28e* (Sea-Bird Electronics Inc.). This new software allows numerical data to be listed to the screen in real time, together with several graphs of various parameters.

Four files were created by the *Seasave Win32 version 5.28e* module for each station:

jcr193_0nn.dat - a binary data file

jcr193_0nn.con - an ASCII configuration file containing calibration information

jcr193_0nn.hdr - an ASCII header file containing the sensor information

jcr193_0nn.bl - a file containing the data cycles at which a bottle was closed on the rosette (nn refers to the CTD cast number).

These files were saved directly to the /jrua/pstar drive.

The CTD data were converted to ASCII and calibrated by running the Sea-Bird Electronics Inc. Data Processing software version 5.37b *Data Conversion* module. This program was used only to convert the data from binary, although it can be used to derive variables. This output an ASCII file *193ctdnn.cnv* to match the names from previous cruises.

The Sea-Bird Electronics Inc. Data Processing software version 5.37b was then used to apply a cell thermal mass correction. This correction takes the output from the data conversion program and re-derives the pressure and conductivity to take into account the temperature of the pressure sensor and the action of pressure on the conductivity cell. The final ASCII output file is of the form *193ctdnn_ctm.cnv*. This correction followed the algorithm:

$$\begin{aligned} \text{Corrected Conductivity} &= c + ctm, \text{ where,} \\ ctm &= (-1.0 * b * \text{previous } ctm) + (a * dcdt * dt), \\ dt &= (\text{temperature} - \text{previous temperature}), \\ dcdt &= 0.1 * (1 + 0.006 * (\text{temperature} - 20)), \\ a &= 2 * \alpha / (\text{sample interval} * \beta + 2) \\ \text{and } b &= 1 - (2 * a / \alpha) \text{ with } \alpha = 0.03 \text{ and } \beta = 7.0 \end{aligned}$$

All processed files were saved to the //jrual/pstar drive, and the *_ctm.cnv*, *.ros* and *.bl* files also copied to *~/pstar/data/ctd/ASCII_FILES/*.

The pressure sensor was calibrated following:

$$P = C \left(1 - \frac{T_0^2}{T^2} \right) \left(1 - D \left(1 - \frac{T_0^2}{T^2} \right) \right)$$

where P is the pressure, T is the pressure period in μS , U is the temperature in degrees Centigrade, D is given by $D = D_1 + D_2 U$, C is given by $C = C_1 + C_2 U + C_3 U^2$, T_0 is given by $T_0 = T_1 + T_2 U + T_3 U^2 + T_4 U^3 + T_5 U^4$.

The conductivity sensor was calibrated following:

$$cond = \frac{(g + h f^2 + i f^3 + j f^4)}{10(1 + \delta t + \varepsilon p)}$$

where p is pressure, t is temperature, and $\delta = CTcorr$ and $\varepsilon = Cpcorr$.

The temperature sensor was calibrated following:

$$Temp(ITS-90) = \left\{ \frac{1}{g + h(\ln(f_0/f)) + i(\ln^2(f_0/f)) + j(\ln^3(f_0/f))} \right\} - 273.15$$

where f is the frequency output by the sensor.

The oxygen sensor was calibrated following:

$$oxygen(ml/l) = [Soc (V + Voffset)] e^{Tcor \cdot T} Oxsat(T,S) e^{Pcor \cdot P}$$

where V is voltage output from SBE43, T temperature, S Salinity, $Oxsat(T,S)$ is oxygen saturation and P pressure while Soc , $Tcor$, $Pcor$ are the constants from calibration sheet characteristic to instrument.

PAR/Irradiance sensor was calibrated following:

$$PAR = \frac{\text{multiplier} (10^9 10^{(V-B)/M})}{calconst} + offset$$

where calibration constants M and B are dependent on sensor type, V is output voltage while multiplier, cal.const and offset are the constants from calibration sheet characteristic to instrument.

Fluorometer was calibrated following:

$$conc(\mu g/l) = slope \frac{[10^{V/SF} - 10^{VB}]}{[10^{V1} - 10^{V_{acetone}}]} + offset$$

where V is output voltage measured by CTD and VB, V1, V_{acetone}, SF, offset are the constants from calibration sheet characteristic to instrument.

Numerical values for all of the constants can be found in Appendix 2, which includes the configuration report for the cruise.

1.5. Problems

1.5.1. Problems during set-up

During the changeover of CTD sensors from the BAS frame to NOC's frame we have encountered problems in bolting the CTD control unit into the existing clutches on NOC's frame. As the clutches were just a little bit too narrow for the CTD, in consultation with ship's engineer and CTD technician, we have removed the protective rubber from the clutches and placed tape over the CTD where the clutches come. This allowed us to bolt the CTD onto the NOC frame and also protected the CTD unit from damage.

There were difficulties in connecting particular instruments to the CTD control unit, as each may require a particular cable, and the BAS cable database system had been updated, but without an appropriate version on ship. Thus there were considerable delays (whole weekend) in identifying which cables could be used, as the information was back in Cambridge. We were unable to use the high-precision temperature sensor (SBE 35) that has been used on previous cruises, because this requires a Y-cable to connect it to the same signal that fires the bottles. When setting up sensors on the CTD frame we could not use all that we wanted because of the apparent restriction on the number of channels (nine measurements in total). We would have to add in a transmissometer (and possibly a duplicate oxygen sensor). This could be a serious constraint on later cruises, as technology improves for nitrate sensors for example.

The CTD instruments and sensors were not preconfigured in *Seasave Win32* and the CTD technician did not know how to do it or use the software. Fortunately, due to the significant delay in departure, there was just enough time for the science party to go through all the manuals and calibrate and configure instruments on our own and use the first CTD station to test bottle firing and the entire calibration and software configuration.

For Station 1 we did not setup sequential bottle firing system to fire every second bottle as we have mounted only 12 bottles. For the rest of the stations we have managed to setup firing system in *Seasave Win32* software.

Finally, small font size on the screen display made work for the CTD operator uncomfortable. This problem was solved by a change of screen resolution on the computer.

1.5.2. Problems during operations

Headers of ASCII .cnv files for stations 01 - 05 included a previous cruise number 165 as we were not aware of the option to add additional information to header. As *pstar* processing creates its own header and discards ASCII file header we have concluded that this does not cause a problem but we corrected headers for all future stations.

Data for Station 8 were erroneously saved as Station 9 but the error was noticed and file names were promptly changed.

Analyzing vertical profiles for the first 17 stations we came to the conclusion that there was a problem with the oxygen sensor in the last hundred metres of a cast that coincided with activation of altimeter measurements. The conclusion was that we had a voltage disruption on this channel when the altimeter gets near the bottom. This appeared to be interference between the signals on channels AUX 3 & AUX 4. To solve the problem we switched the oxygen and PAR sensors (so oxygen was then on AUX 2), as one does not need irradiance measurements near the bottom. It should be noted that signals transmitted by the frequency channels, such as temperature, cannot interfere with signals being returned via the voltage channels. Also we have changed configuration file in *Seasave* software having *jr193_final.con* and *jr193_final_second_part.con* for the first 17 stations and stations 18 - 42 respectively. In Appendix 2 configuration constants are given for stations 18 - 42.

2. CTD Data Processing and Calibration

As CTD stations include two sections Drake Passage SR1b and Marguerite Trough respectively, two different data processing schemes were made; one according to NOCS using UNIX pstar (stations 1-32), and the other to BAS standards using MATLAB routines (stations 33-42).

2.1. NOCS Standard Processing (*pstar*)

The final Unix CTD files were a 1 Hz time series for the full cast (for use in LADCP processing, for example), and a 1db file of the downcast. Following the procedure in JR94, to simplify the reprocessing of the scan numbers for the start of the downcast maximum depth and end of cast were selected from the 24 Hz file, and entered into a file called 193station_dcs. Scripts requiring knowledge of these scan numbers interrogate this file. The scan number for the bottom of file was found automatically using *refval*. The start and end scan numbers were found from listings to the screen, judging the start of the downcast after hauling to the near surface, and selecting a scan number shortly before the CTD broke the surface at the end of the cast.

Routines used:

- 193seactd0 - This exec converts the seabird ascii file *193ctd[nn]_ctm.cnv* to pstar.
- 193seactd1 - This exec calculates the salinity and potential temperature, creating the file *193ctd[nn].sal*
- 193seactd1.1 - Obtains the data cycle for the bottom of the cast in the *.sal* file and adds it to *193stations_dcs*.
- 193seactd1.2 - This produces listings of the pressure and salinity near the start and near the end of the cast for extraction of start and end cycle numbers.
- 193seactd1.3 - This exec inserts the noted start and end cycle into *193stations_dcs*.
- 193seactd2 - This extracts data from *193ctd[nn]* corresponding to the bottle firing times taken from the Seabird ascii file *193ctd[nn].bl*. Data were extracted for 3 seconds before the bottle closed and 5 seconds after the bottle closed. The extracted data are averaged to give a file containing a single data cycle for each bottle firing. The output file is *193ctd[nn].btl*.
- 193seactd7 - This performs averaging to output files *193ctd[nn].1hz* (which has both downcast and upcast) and *193ctd[nn].1db* (which only has downcast).

2.2. BAS Standard Processing (*Matlab*)

CTD stations 33-42 were part of BAS cruise JR171, and were processed using in house Matlab code.

2.3. Calibration

There are two opportunities for CTD data calibration/comparison: Internal check between the primary and secondary sensors and comparison with salinity samples. We use the notation T1, T2, C1, C2, S1, S2 for CTD sensors and S for salinity samples.

Primary/Secondary comparison: An initial comparison was made. The mean and one standard deviation differences were:

$$\begin{aligned} T1 - T2 &= (0.6 \pm 0.5) \cdot 10^{-3} \text{ }^{\circ}\text{C} \\ C1 - C2 &= (1.0 \pm 0.4) \cdot 10^{-3} \text{ mmho cm}^{-1} \\ S1 - S2 &= (0.6 \pm 0.2) \cdot 10^{-3} \text{ psu} \end{aligned}$$

2.4. Initial results

Aside from the problems with the oxygen sensor (see section 2.5.), all instruments worked well. The following figures show the data across the two main sections. These show data prior to final calibrations. The plots for Drake Passage (JR193) are as function of latitude, moving south, and cover CTD stations 3-32; those for Marguerite Trough (JR171) are as a function of distance from south western-most point, and correspond to CTD stations 33 - 41.

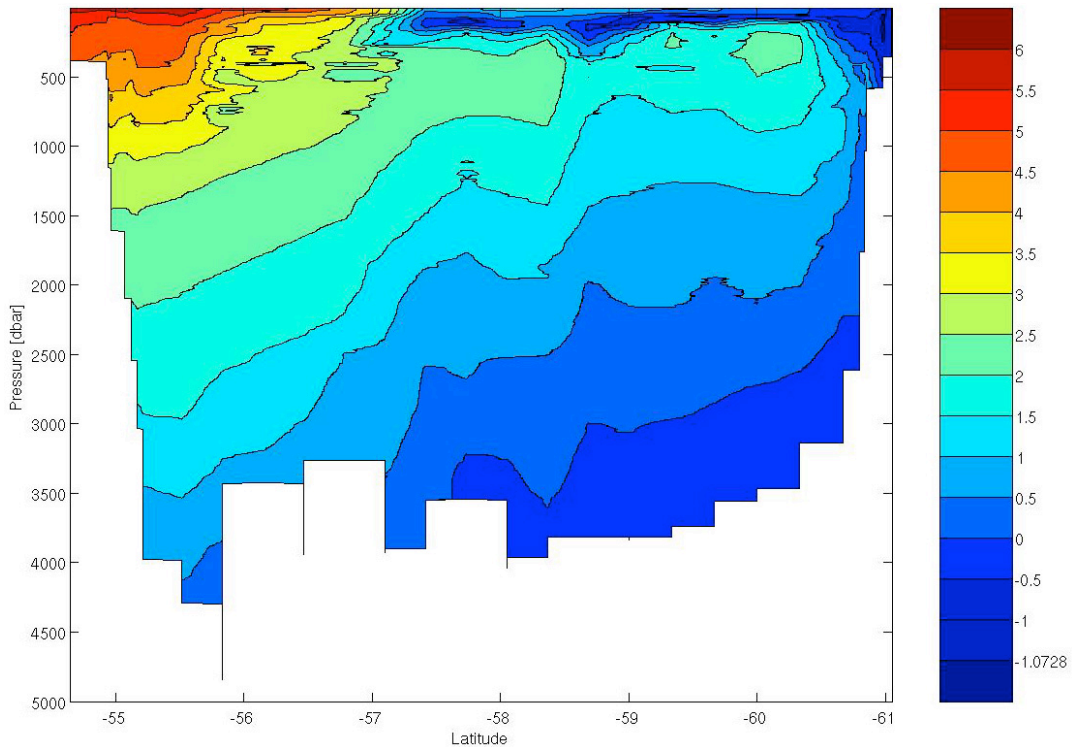


Figure 2: Plot of temperature ($^{\circ}\text{C}$) for Drake Passage section of JR193

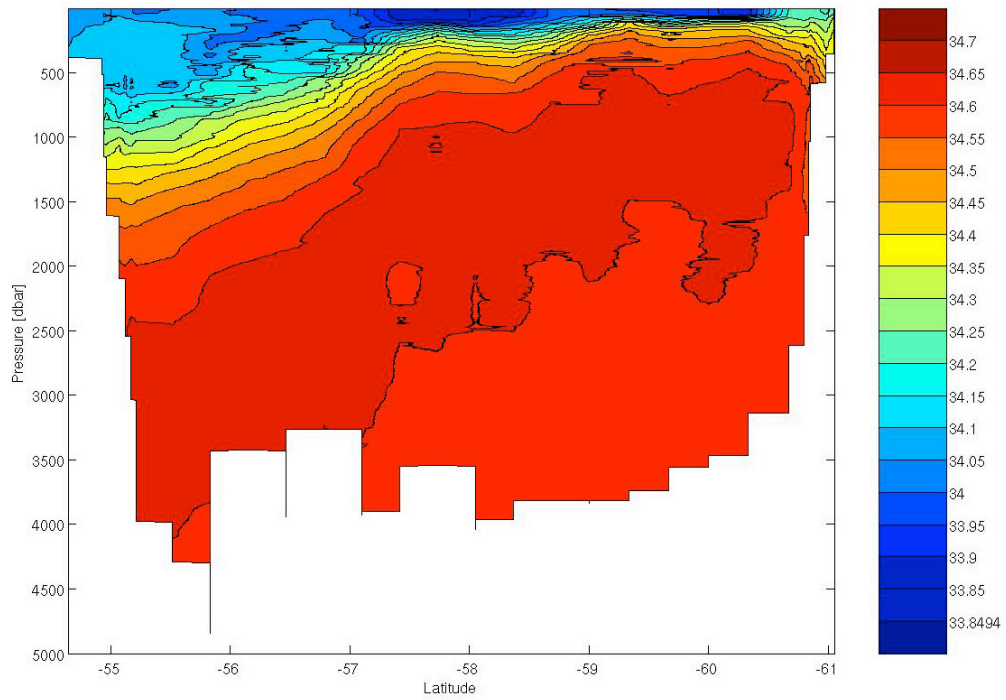


Figure 3: Plot of salinity (psu) for Drake Passage section of JR193

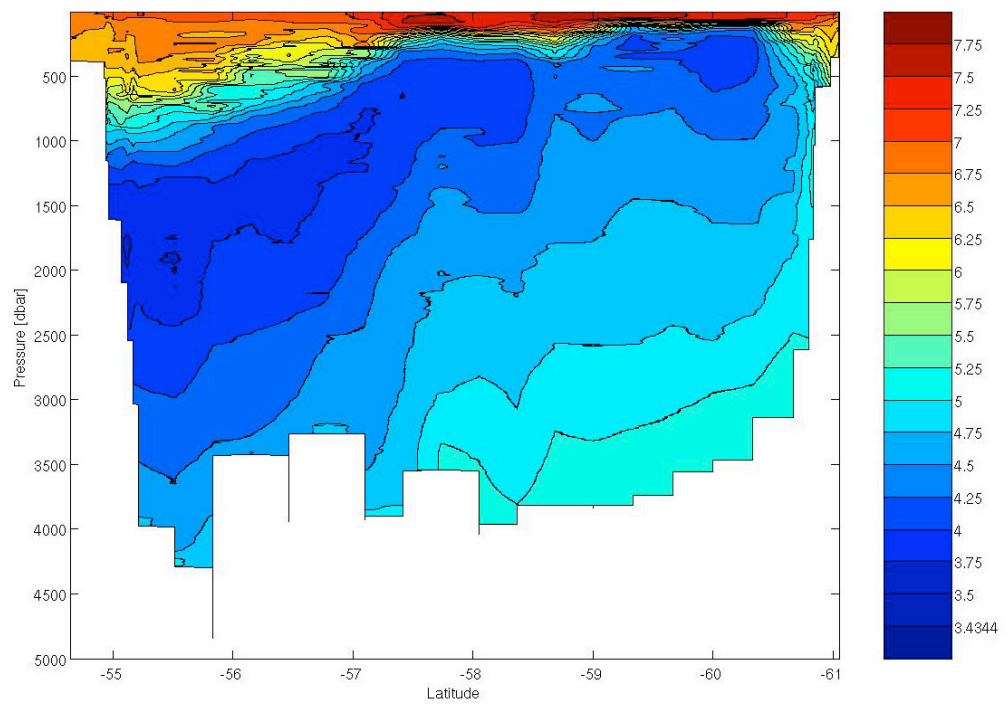


Figure 4: Plot of oxygen (ml/l) for Drake Passage section of JR193

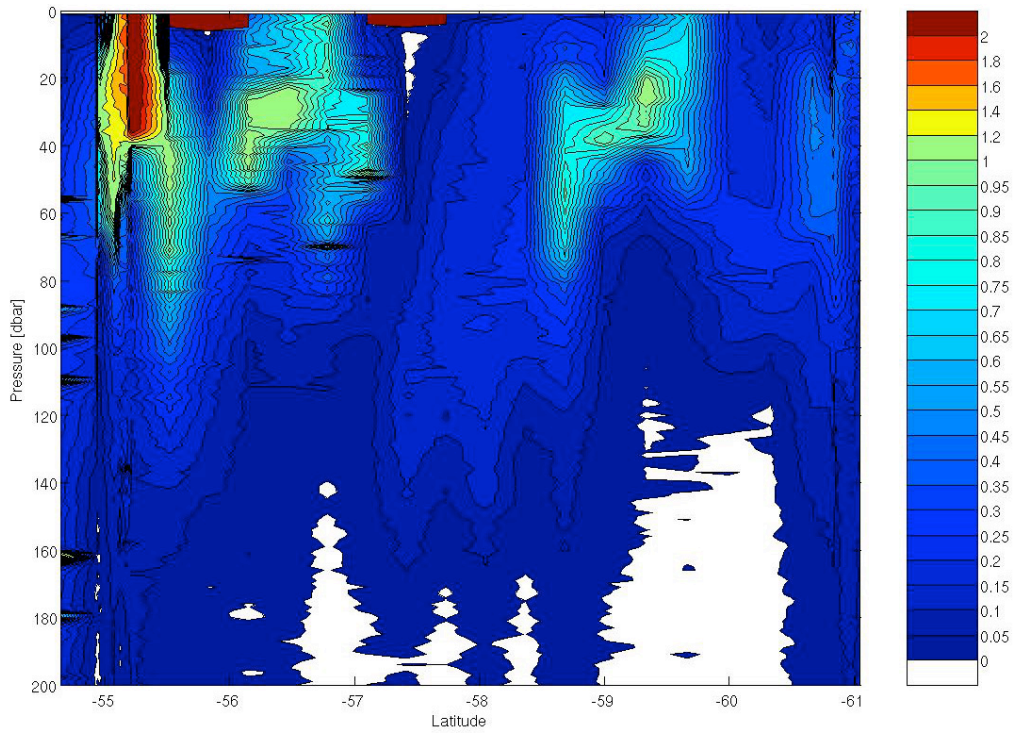


Figure 5: Plot of fluorescence (mg m^{-3}) in top 200m for Drake Passage section of JR193

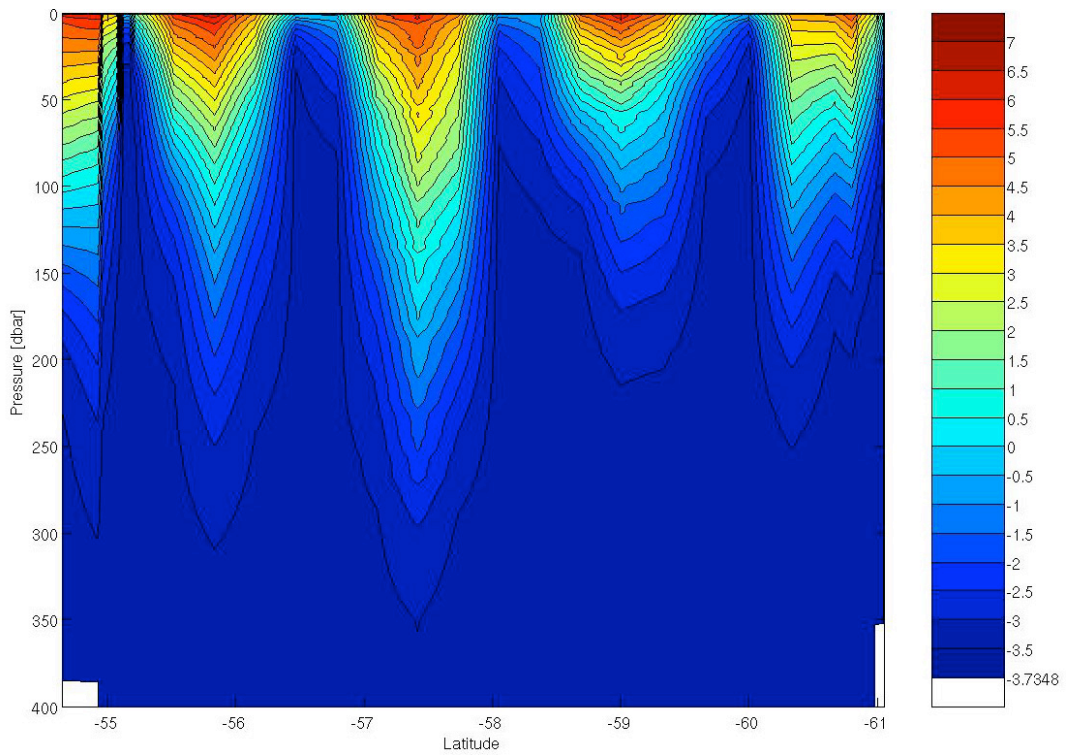


Figure 6: Plot of $\ln(\text{PAR})$ in the top 400m for Drake Passage section of JR193. The five pronounced features are due to the periods of good daylight; value of PAR changes by a factor of about 100 in the first 100m.

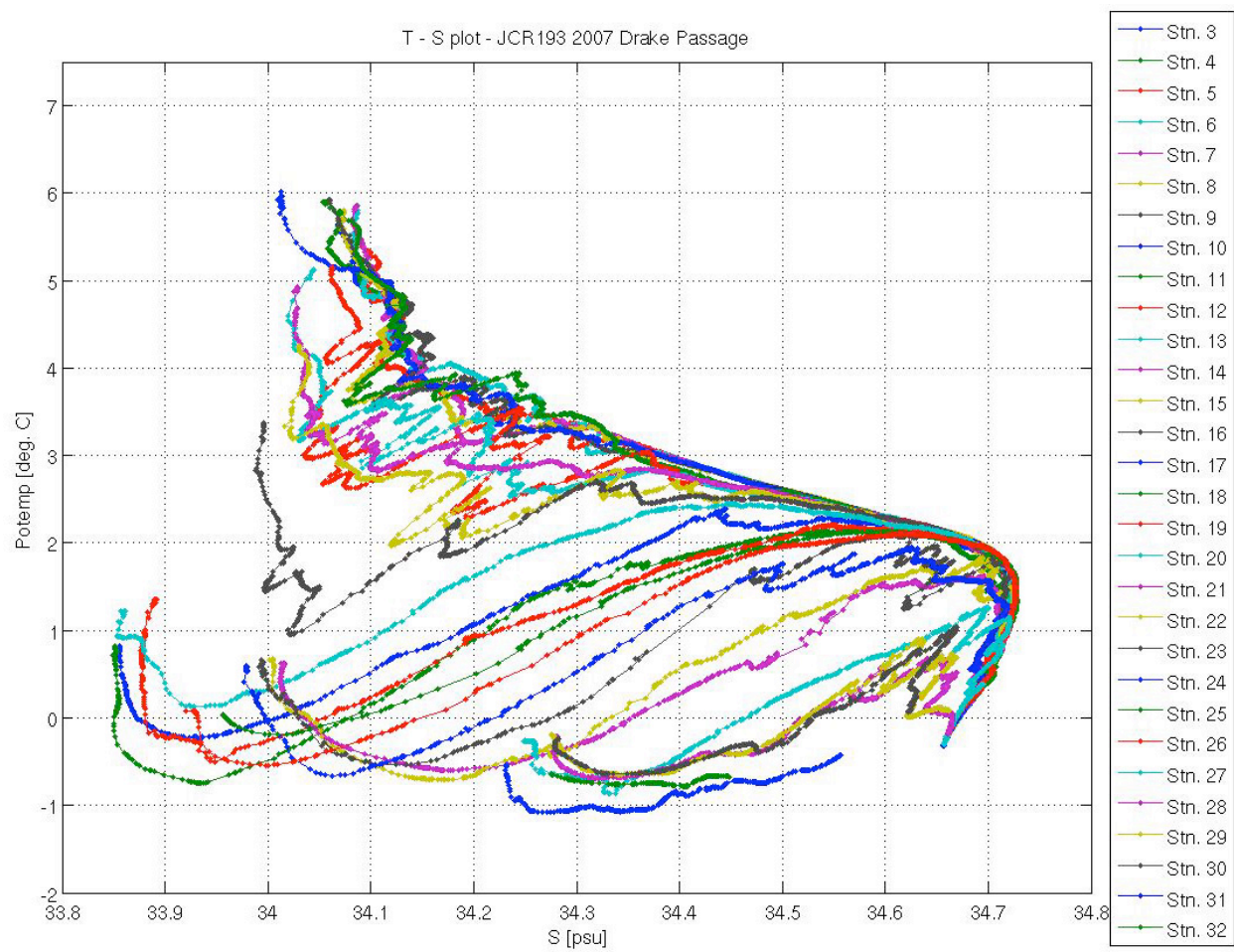


Figure 7: T-S plot for Drake Passage section of JR193

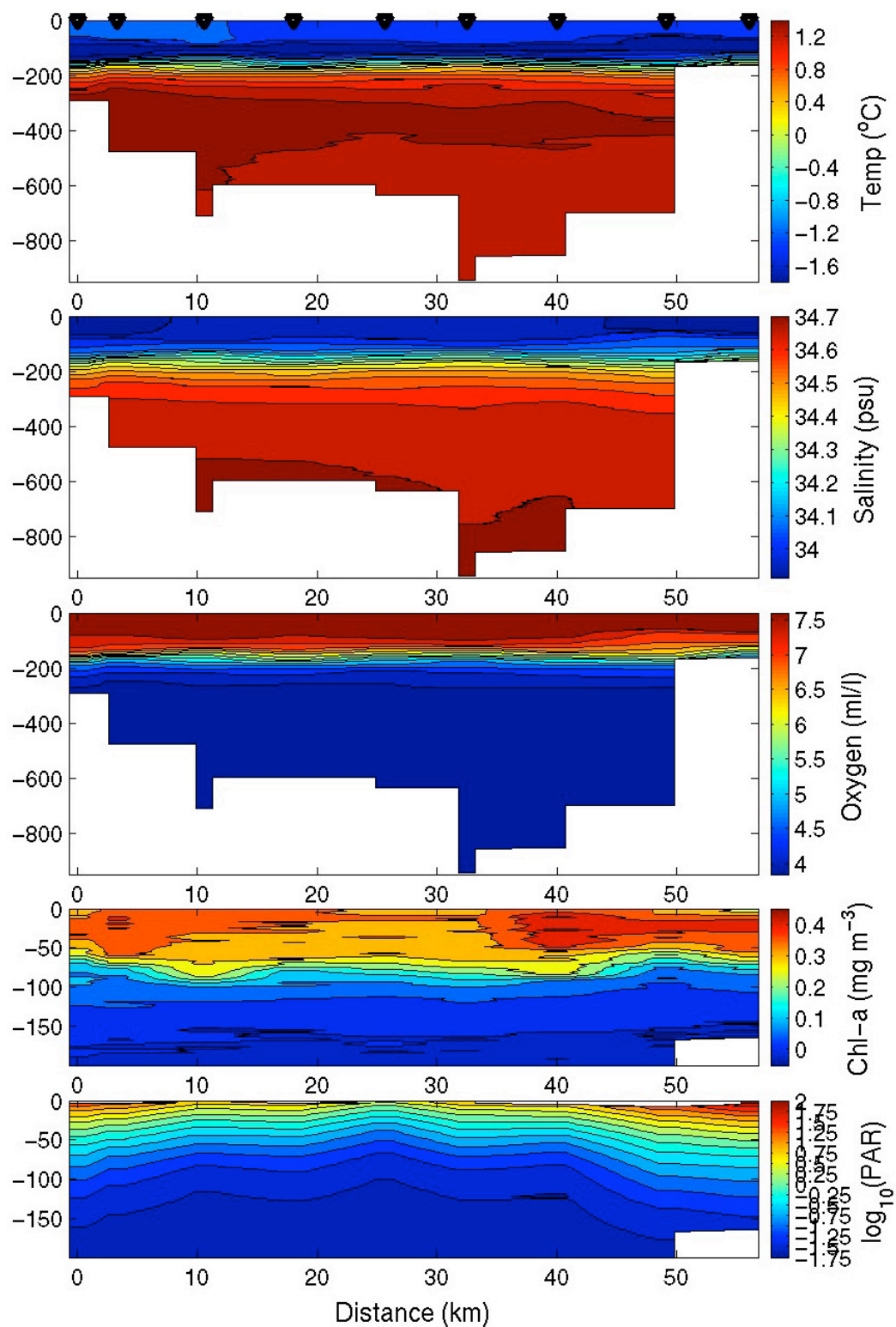


Figure 8: Measured parameters for JR171 CTD section across Marguerite Trough, starting (distance=0) at SW end. Triangles on top of first panel show locations of CTD stations.

2.6. Post Cruise Calibration

Sally Close and Brian King carried out calibration of the CTD data for JR193 at NOCS after completion of the cruise. The raw CTD data and sample data were used as input files and the data were processed using the NOCS in-house mstar processing routines. Corrections were calculated and applied to conductivity values, which were then reprocessed to provide corrected salinity values.

Conductivity data for CTD sensors 1 and 2 were examined, and a slight pressure effect was noted for sensor 2. It was hence decided to correct the sensor 1 data for the calibration. Conductivity bottle and CTD sensor values were compared and residuals were examined with respect to station number. Suspected bad bottles were marked in the final data file using a quality flag, and a final correction was calculated using only data deeper than 900dbar, to remove surface variability.

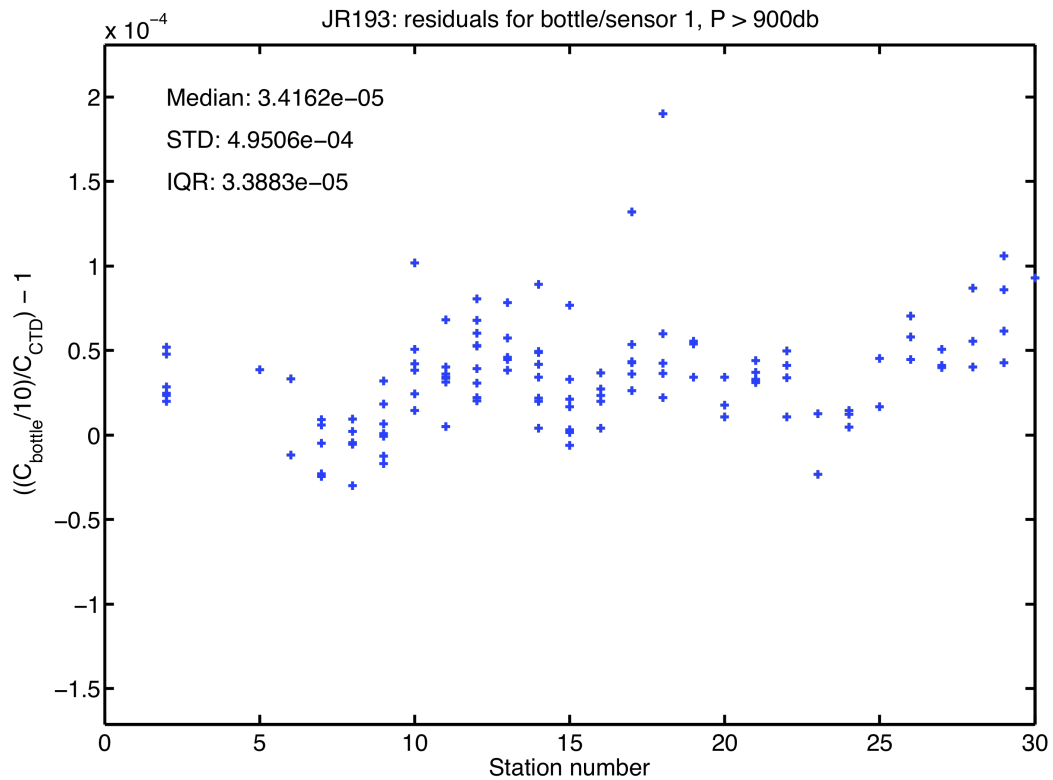


Figure 9: Residuals calculated from bottle conductivities and sensor 1 conductivities for data collected below 900db.

A single uniform correction of $+3.4 \times 10^{-5} \pm 3.4 \times 10^{-5}$ was applied to the conductivity values of sensor 1 in the original 24Hz mstar files, corresponding to an approximate correction of $+0.001 \pm 0.001$ in salinity. After correction, the mean value of the residuals was -1.1745×10^{-6} , with a median of -1.4545×10^{-7} and an interquartile range of 3.3093×10^{-5} . 72% of the values lie within 1 standard deviation of the mean, with 95% lying within 2 standard deviations.

Marko Pavić, Sally Close, and Brian King

3. Salinometer

3.1. *Setting up the Autosol*

Do this well in advance of the first CTD, to allow time for the water bath to equilibrate to room temperature and to perform checks.

Connect the deionised water supply to the tank fill/drain nozzle and run a tube from the tank overflow to the drain/sink. Make sure the tank fill/drain valve is open and fill the chamber until water runs out of the overflow.

Turn off the water supply. Close the tank drain/fill knob and remove the tubing from the nozzle. Making sure the standby/read/zero switch is set to standby, turn on the unit at the mains.

Set the bath temperature to 2-3°C above ambient temperature (it was set to 24°C in the bio lab on JR193). The heating lamps in the water bath should come on until the water has come to the right temperature, and then flash on intermittently as the heat is maintained a few degrees above ambient.

A short length of tubing should be connected to the cell drain valve. Ideally this should drain into an isolated bucket that it does not touch. The cell drain must not provide an electrical path to ground, nor must it be long enough to cause a siphoning effect out of the conductivity cell. On JR193, after experiencing problems with this latter effect, the cell drain tube was made as short as possible (< 10 cm), draining into a mop bucket suspended from the edge of the bench.

When not in use, the conductivity cell should be filled with deionised water. To fill the chamber, jam the bottle onto the rubber bung, making an airtight seal and switch on the pumps. The chamber should fill, with all 4 electrodes completely submerged. Flush the cell by placing a finger over the flush hole, until completely drained and no significant flow is coming out of the cell drain tube. Allow the chamber to fill again.

When the chamber is full again, switch the function knob to read, and turn the suppression knob fully anticlockwise. The readout should be no higher than 0.0 ± 0.050 . When finished with the reading, switch back to standby.

If the reading is higher, flush and fill again, repeating until it is lower. Then switch off the pumps, leaving the chamber full. Note that the function knob should never be switched to read unless the cell is full. Doing otherwise can damage the cell, and lead to unstable readings.

3.1.1. Notes

Upon boarding the ship, the salinometer had been set up with an additional peristaltic pump unit. The Autosal internal pumps require an airtight seal to be made around the neck of the sample bottle at the sample intake tube. The external pump removes this requirement, and also allows quicker filling of the conductivity cell.

However, a significant drawback of this technique is that the external pump requires a longer sample intake tube, and this can harbour bubbles, which can significantly affect the conductivity reading. This problem was also noted in the previous year's Drake Passage cruise report (JR163) and was solved then and on JR193 by using the internal pumps only, with a shorter intake tube.

To minimise air bubbles in the conductivity cell, it was necessary to prevent air entering at the cell uptake tube, and this was done by never having the pumps switched on when the tube was not submerged. However, when the pumps are switched off, there can be a small reverse flow out of the sample tube. This can cause contamination when swapping sample bottles, and was minimised by turning the flow rate knob down by one revolution when swapping bottles (see step by step instructions for more details).

3.2. Standardisation procedure

Do this before and after each crate of samples.

- 1) Note bottle details, time/date and lab temperature. Work out twice the conductivity ratio shown on the standard seawater vial label.
- 2) Gently agitate the bottle, this is very important as salinity gradients can develop in the standards and samples.
- 3) Switch on the pumps and flush the cell. While still holding flush, switch off the pumps and turn the flow rate down by 1 revolution.
- 4) Open the vial and insert the sample intake tube (which should be first wiped with a clean tissue). Jam the bottle onto the rubber bung, making an airtight seal.
- 5) Switch on Autosol pumps and turn up the flow rate to maximum.
- 6) Fill and flush the chamber three times.
- 7) Allow the chamber to refill and switch the function knob to '**read**'.
- 8) Adjust the suppression knob until the display stops flashing and shows a positive reading (usually a suppression of 1.9 for seawater).
- 9) Wait for the reading to stabilise, and note the entire display.
- 10) Switch to '**standby**' and flush the chamber.
- 11) Repeat steps **6-9** until 3 consecutive (near) identical readings are obtained.
(± 2 in last digit)
- 12) For first standardisation of the cruise only, while the chamber is still full, switch the function knob to '**read**' and adjust suppression knob so that the display matches the 2*vial conductivity ratio calculated in step 1.
- 13) Flush the chamber, and while still holding a finger over flush, switch off the pumps and turn the flow rate down by 1 revolution.
- 14) Remove the SSW vial, wipe tube and fill and flush chamber 3 times with MilliQ (remembering to turn up the flow rate).
- 15) Allow chamber to refill with MilliQ and switch pumps off.
- 16) Note last four digits of the display (this is a sign of electrical drift, and should not change by more than ± 5 in the last digit between standardisations).
 - Always make sure the function switch is set to standby when flushing chamber.
 - Make sure the pumps are off when sample intake is not submerged.

As can be seen from Table 3 the standardisation value was changed several times throughout the cruise (see the bold/italic values). In addition to this a large number of salinity samples are shown in this table to have not been analysed.

3.3. Processing a crate of samples

- 1) Run standardisation procedure.
- 2) Note bottle identity.
- 3) Gently agitate the bottle.
- 4) Flush the chamber of its contents, and while still holding flush, switch off the pumps and turn the flow rate down by 1 revolution.
- 5) Open the bottle using a clean tissue, wipe the sample intake tube and place it in the sample bottle, jamming the bottleneck against the rubber bung.
- 6) Turn on the Autosol pumps and turn the flow rate up to maximum.
- 7) Fill and flush the cell chamber 3 times
- 8) Allow the chamber to fill and switch the function knob to '**read**'.
- 9) Adjust the suppression knob until the display stops flashing and shows a positive reading.
- 10) Wait for the reading to stabilise, and note the entire display.
- 11) Switch to '**standby**' and flush the chamber.
- 12) Repeat steps **8-11** until 3 consecutive near-identical readings are obtained (variation should not be more than ± 2 in the last digit).
- 13) Repeat steps **2-12** for each sample in the crate.
- 14) At the end of the crate, note lab temp and run another standardisation procedure.

At the end of processing, switch to '**read**', suppression to **zero** and pump ~400 ml of MilliQ through the cell, or until **readout** < **0.0±0050**.

Leave the unit with pumps switched off and the chamber full of MilliQ.

- Always make sure the function switch is set to standby when flushing chamber.
- Make sure the pumps are off when sample intake is not submerged.

3.4. CTD/sample salinity comparison

Salt samples were taken for calibration of the CTD salinity profiles. Each 200ml medicine bottle was rinsed three times and then filled to just below the neck, to allow expansion of the (cold) samples, and to allow effective mixing upon shaking of the samples prior to analysis. The rim of each bottle was wiped with a tissue to prevent salt crystals forming upon evaporation, a plastic seal was inserted into the neck of the bottle and the screw cap was replaced. The bottle crates were colour coded and numbered for reference. The salinity samples were placed close to the salinometer (sited in the biology lab), and left for at least 24 hours before measurement. This allowed the sample temperatures to equilibrate with the ambient temperature of the biology lab.

The samples were then analysed on the BAS Guildline Autosol model 8400B, S/N 63360 against Ocean Scientific standard seawater (hereafter OSIL) from batch P147. At the beginning, and at the end of each crate of samples one vial of OSIL standard seawater was run through the salinometer enabling a calibration offset to be derived and to check the stability of the salinometer.

As with previous years, several problems were encountered during the analysis of the salt samples. In particular, the salinometer readings were found to be highly unstable. The fluctuating readings observed here were caused by the presence of small bubbles in the cell. Similar problems were noted during the previous cruises (Hawker 2005, Williams and Hadfield 2008) and were thought to have been fixed by replacing the new external pump with an old peristaltic pump. After analysing the first 3 stations the old external pump was removed and samples were forced into the cell using air.

Once analysed, the conductivity ratios were entered by hand into an Excel spreadsheet, converted to salinities and saved on the Unix system. Using the routines *193samblank.exec*, *193samfir_new* and *botcond*, the bottle conductivities were computed for comparison with the CTD conductivity sensors.

Table 3: List of salinity samples run and their associated standards and ratios. Bold and italic values highlight points where the value of the standard changed.

CTD	Niskin	Standard	Ratio 1	Ratio 2	Ratio3	Salinity
2	<i>1</i>	<i>NaN</i>	<i>NaN</i>	<i>NaN</i>	<i>NaN</i>	<i>NaN</i>
2	2	1.99961	1.98528	1.98529	1.98531	34.71076141
2	3	1.99961	1.98094	1.98095	1.98095	34.62534808
2	4	1.99961	1.98093	1.98092	1.98091	34.62482417
2	5	1.99961	1.97636	1.97635	1.97636	34.53518951
2	6	1.99961	1.97633	1.97635	1.97635	34.53492766
2	7	1.99961	1.96503	1.96504	1.96505	34.31306258
2	8	1.99961	1.95655	1.95653	1.95653	34.14630593
2	9	1.99961	1.95557	1.95559	1.95558	34.12755301
2	10	1.99961	1.95499	1.95502	1.95501	34.11631511
2	11	NaN	NaN	NaN	NaN	NaN
2	12	1.99961	1.95343	1.95345	1.95347	34.08580583
2	13	NaN	NaN	NaN	NaN	NaN
3	3	1.99961	1.95418	1.95419	1.95419	34.1002433
3	5	1.99961	1.95355	1.95355	1.95357	34.08789626
3	7	1.99961	1.95328	1.95328	1.95326	34.08234359
3	9	1.99961	1.95283	1.95281	1.95282	34.07345961
3	11	1.99961	1.95269	1.95271	1.9527	34.07110803
4	1	1.99961	1.95568	1.95567	1.95569	34.12951317
4	3	1.99961	1.95535	1.95534	1.95533	34.1228487
4	5	1.99961	1.95531	1.95532	1.95532	34.12239135
4	7	NaN	NaN	NaN	NaN	NaN
4	9	1.99961	1.95245	1.95247	1.95248	34.06653558
4	11	1.99961	1.95309	1.9531	1.9531	34.07888141
5	1	NaN	NaN	NaN	NaN	NaN
5	3	1.9996	1.96629	1.96631	1.96629	34.33771761
5	5	1.9996	1.95756	1.95758	1.95757	34.16656352
5	7	NaN	NaN	NaN	NaN	NaN
5	9	<i>1.99953</i>	<i>1.95567</i>	<i>1.95568</i>	<i>1.95567</i>	<i>34.1293825</i>
5	11	1.99953	1.95309	NaN	1.95309	NaN
6	1	1.99953	1.97895	1.97893	1.97894	34.58592776
6	3	1.99953	1.97128	1.97126	1.97127	34.43531881
6	5	1.99953	1.96168	1.96168	1.9617	34.24728593
6	7	1.99953	1.95571	1.95572	1.9557	34.13010123
6	9	NaN	NaN	NaN	NaN	NaN
6	11	NaN	NaN	NaN	NaN	NaN
7	1	1.99953	1.98297	1.98296	1.98295	34.66490653
7	2	1.99953	1.98245	1.98243	1.98246	34.65481976
7	3	1.99953	1.97737	1.97737	1.97737	34.55509058
7	4	1.99953	1.97	1.97001	1.97002	34.41058728
7	5	1.99953	1.96525	1.96524	1.96523	34.31698627
7	6	1.99953	1.95844	1.95847	1.95845	34.18388199
7	7	1.99953	NaN	1.95659	1.95657	NaN
7	8	1.99953	1.95555	1.95554	1.95554	34.12683429
7	9	1.99953	1.95576	1.95575	1.95576	34.13101597
7	10	1.99953	1.95472	1.95473	1.95473	34.11082704
7	11	1.99953	1.95426	1.95428	1.95428	34.10194189

7	12	1.99953	1.95333	1.95332	1.95331	34.08325814
8	1	1.99958	1.98453	1.98454	1.98454	34.69589027
8	2	1.99958	1.98455	1.98454	1.98456	34.69615231
8	3	1.99958	1.98229	1.9823	1.9823	34.65187241
8	4	1.99958	1.97648	1.97648	1.9765	34.5377425
8	5	1.99958	1.97644	1.97643	1.97645	34.53682604
8	6	1.99958	1.9662	1.96621	1.96621	34.33595177
8	7	1.99958	1.95762	1.9576	1.9576	34.16728237
8	8	1.99958	1.9544	1.95439	1.9544	34.10435914
8	9	1.99958	1.95473	1.95473	1.95471	34.11076171
8	10	1.99958	1.95593	1.95595	1.95595	34.13467501
8	11	1.99958	1.95457	1.95457	1.95456	34.10769107
8	12	1.99958	1.95264	1.95265	1.95265	34.07006289
9	1	1.99958	1.98568	1.98569	1.9857	34.71855769
9	2	1.99958	1.98577	1.98576	1.98575	34.71993354
9	3	1.99958	1.98488	1.9849	1.98489	34.70283437
9	4	1.99958	1.98278	1.98276	1.98276	34.66110756
9	5	1.99958	1.98281	1.9828	1.98279	34.66176255
9	6	1.99958	1.97659	1.97657	1.97657	34.53950998
9	7	1.99958	1.96543	1.96543	1.96541	34.32058305
9	8	1.99958	1.95491	1.95492	1.95493	34.11461641
9	9	1.99958	1.95572	1.95574	1.95572	34.13042792
9	10	1.99958	1.9551	1.9551	1.9551	34.1181445
9	11	1.99958	1.95446	1.95447	1.95448	34.10579643
9	12	1.99958	1.9519	1.95192	1.95191	34.05562743
10	1	1.99952	1.99498	1.99498	1.99497	34.90116216
10	2	1.99952	1.98558	1.98557	1.98558	34.71633015
10	3	1.99952	1.98572	1.98574	1.98573	34.71934389
10	4	1.99952	1.98486	1.98486	1.98488	34.70237579
10	5	1.99952	1.98219	1.98217	1.98217	34.64951456
10	6	1.99952	1.97706	1.97707	1.97708	34.54919863
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10	9	1.99952	1.9552	1.95522	1.95522	34.12036591
10	10	1.99952	1.9551	1.95509	1.95509	34.11801382
10	11	1.99952	1.9538	1.95379	1.95378	34.09246916
10	12	1.99952	1.94991	1.9499	1.9499	34.01631036
11	1	1.99952	1.984	1.98399	1.98398	34.685147
11	2	1.99952	1.98481	1.9848	1.98479	34.70106557
11	3	1.99952	1.98578	1.98578	1.9858	34.72045767
11	4	1.99952	1.98568	1.98568	1.9857	34.71849218
11	5	1.99952	1.98481	1.98483	1.98483	34.70152415
11	6	1.99952	1.98282	1.98282	1.98281	34.66209005
11	7	1.99952	1.97873	1.97871	1.97872	34.58160636
11	8	1.99952	1.97121	1.97123	1.97121	34.43427192
11	9	1.99952	1.95541	1.95542	1.9554	34.12422078
11	10	1.99952	1.95596	1.95596	1.95596	34.13500171
11	11	1.99952	1.95357	1.95357	1.95355	34.08802692
11	12	1.99952	1.9499	1.9499	1.9499	34.01624506
12	1	1.9995	1.98342	1.98342	1.98342	34.67394573
12	2	1.9995	1.98344	1.98344	1.98344	34.67433875

12	3	1.9995	1.98393	1.98393	1.98393	34.68396789
12	4	1.9995	1.98519	1.98517	1.98518	34.70853395
12	5	1.9995	1.98576	1.98576	1.98576	34.71993354
12	6	1.9995	1.98577	1.98577	1.98577	34.72013009
12	7	1.9995	1.98574	1.98575	1.98573	34.71954044
12	8	1.9995	1.98453	1.98453	1.98452	34.69569374
12	9	1.9995	1.98029	1.98029	1.98029	34.61244729
12	10	1.9995	1.95255	1.95255	1.95256	34.06823391
12	11	1.9995	1.95289	1.95289	1.95289	34.07483138
12	12	1.9995	1.95139	1.95141	1.95139	34.04556889
13	1	1.9995	1.98512	1.98511	1.98512	34.7072892
13	2	NaN	NaN	NaN	NaN	NaN
13	3	1.9995	1.98583	1.98583	1.98582	34.72124387
13	4	1.9995	1.98575	1.98575	1.98576	34.7198025
13	5	NaN	NaN	NaN	NaN	NaN
13	6	1.9995	1.98495	1.98493	1.98495	34.70388256
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13	8	1.9995	1.98066	1.98066	1.98066	34.61971617
13	9	1.9995	1.97283	1.97282	1.97284	34.4659427
13	10	1.9995	1.96757	1.96757	1.96757	34.36270248
13	11	1.9995	1.95155	1.95154	1.95153	34.0483774
13	12	1.9995	1.9502	1.95019	1.9502	34.02205726
14	1	1.99975	1.98407	1.98407	1.98407	34.68671915
14	2	1.99975	1.98551	1.9855	1.9855	34.71488882
14	3	1.99975	1.9858	1.9858	1.98582	34.72085077
14	4	1.99975	1.98577	1.98578	1.98578	34.72026112
14	5	1.99975	1.98565	1.98564	1.98563	34.71757495
14	6	1.99975	1.98511	1.9851	1.98511	34.70709266
14	7	1.99975	1.98245	1.98245	1.98245	34.65488525
14	8	1.99975	1.98147	1.98147	1.98147	34.63562997
14	9	1.99975	1.9759	1.97589	1.9759	34.52615606
14	10	1.99975	1.97053	1.97052	1.97052	34.42066275
14	11	1.99975	1.95067	1.95066	1.95066	34.03120037
14	12	1.99975	1.95044	1.95045	1.95046	34.02702062
15	1	1.99975	1.98478	1.98479	1.98478	34.70073802
15	2	1.99975	1.98508	1.98508	1.98509	34.70663407
15	3	1.99975	1.98524	1.98524	1.98523	34.70964767
15	4	1.99975	1.98557	1.98558	1.98558	34.71633015
15	5	1.99975	1.98572	1.9857	1.9857	34.71888527
15	6	1.99975	1.98549	1.98547	1.98549	34.71449573
15	7	1.99975	1.98403	1.98405	1.98405	34.6861951
15	8	1.99975	1.98307	1.98308	1.98307	34.66713355
15	9	1.99975	1.97826	1.97826	1.97825	34.57250552
15	10	1.99975	1.97399	1.974	1.97401	34.48891344
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16	3	1.99954	1.9852	1.9852	1.9852	34.70892703
16	4	1.99954	1.98543	1.98542	1.98544	34.71344749
16	6	1.99954	1.98583	1.98584	1.98584	34.72144042
16	7	1.99954	1.98555	1.98556	1.98557	34.71600258

16	9	1.99954	1.96789	1.96788	1.96788	34.36885103
16	11	1.99954	1.95073	1.95075	1.95074	34.03270249
16	12	1.99954	1.94918	1.94917	1.94915	34.00187848
17	1	1.99954	1.98366	1.98364	1.98366	34.67853097
17	3	1.99954	1.98432	1.98432	1.98432	34.6916322
17	4	1.99954	1.98477	1.98478	1.98477	34.70054148
17	6	1.99954	1.98462	1.98461	1.98462	34.6974625
17	7	1.99954	1.98585	1.98585	1.98584	34.72163698
17	9	1.99954	1.98508	1.98507	1.98507	34.70643753
17	11	1.99954	1.94239	1.94238	1.94237	33.86896761
17	12	1.99954	1.94162	1.94162	1.9416	33.85395825
18	1	1.99954	1.98289	1.98289	1.98288	34.66346554
18	2	1.99954	1.98366	1.98366	1.98367	34.67872749
18	4	1.99954	1.98527	1.98527	1.98526	34.7102373
18	5	1.99954	1.98557	1.98558	1.98556	34.71619912
18	8	1.99954	1.98444	1.98444	1.98444	34.69399051
18	9	1.99954	1.97998	1.97998	1.98	34.6064883
18	11	1.99954	1.9454	1.94541	1.9454	33.92816683
18	12	1.99954	1.94152	1.94152	1.94153	33.85219635
19	1	1.99952	1.98264	1.98263	1.98263	34.65848762
19	3	1.99952	1.98467	1.98466	1.98466	34.69837964
19	5	1.99952	1.98584	1.98586	1.98586	34.72176801
19	7	1.99952	1.98455	1.98453	1.98454	34.69595578
19	9	1.99952	1.94273	1.94273	1.94272	33.87575479
19	11	1.99952	1.94466	1.94467	1.94466	33.91367556
20	1	1.99952	1.98271	1.98271	1.9827	34.65992858
20	3	1.99952	1.98454	1.98456	1.98455	34.69615231
20	5	1.99952	1.98577	1.98577	1.98576	34.72006457
20	7	1.99952	1.98358	1.98357	1.98356	34.67689338
20	9	1.99952	1.94737	1.94737	1.94738	33.96674969
20	11	1.99952	1.94178	1.9418	1.9418	33.85748209
21	1	1.99952	1.98259	1.98258	1.98257	34.65743965
21	3	1.99952	1.98317	1.98315	1.98316	34.66883657
21	5	1.99952	1.98477	1.98477	1.98478	34.70054148
21	7	1.99952	1.98546	1.98546	1.98547	34.71410264
21	9	1.99952	1.98534	1.98535	1.98535	34.71180963
21	11	1.99952	1.94964	1.94965	1.94963	34.01115135
22	1	1.99952	1.98247	1.98249	1.98249	34.65554022
22	3	1.99952	1.98319	1.98321	1.98319	34.66955709
22	5	1.99952	1.98479	1.98479	1.9848	34.70093455
22	7	1.99952	1.98599	1.98599	1.98598	34.72438871
22	9	1.99952	1.95859	1.95859	1.9586	34.18662693
22	11	1.99952	1.94931	1.94931	1.94931	34.00468642
23	1	NaN	NaN	NaN	NaN	NaN
23	3	NaN	NaN	NaN	NaN	NaN
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23	7	NaN	NaN	NaN	NaN	NaN
23	9	NaN	NaN	NaN	NaN	NaN
23	11	NaN	NaN	NaN	NaN	NaN
24	1	1.99949	1.9824	1.98243	1.98244	34.65436128
24	3	1.99949	1.98288	1.98288	1.98293	34.66366204

24	5	1.99949	1.98425	1.98422	1.98424	34.6899945
24	7	1.99949	1.98511	1.98518	1.98514	34.7078133
24	9	1.99949	1.97495	1.97499	1.97498	34.50802485
24	11	1.99949	1.94813	1.94813	1.94812	33.9815057
25	1	1.99949	1.98249	1.98256	1.98255	34.65652268
25	3	1.99949	1.98497	1.98496	1.98498	34.70440665
25	5	1.99949	1.98608	1.98613	1.98609	34.72661633
25	7	1.99949	1.97742	1.97748	1.97744	34.55659633
25	9	1.99949	1.9653	1.96526	1.96528	34.31777101
25	11	1.99949	1.94715	1.94715	1.94718	33.96257118
26	1	1.99949	1.98252	1.98259	1.98257	34.65704667
26	3	1.99949	1.98433	1.98435	1.98436	34.69215627
26	5	1.99949	1.98466	1.98468	1.98468	34.69857617
26	7	1.99949	1.98606	1.98607	1.98606	34.72589563
26	9	1.99949	1.97747	1.9775	1.97752	34.55757835
26	11	1.99949	1.94525	1.94526	1.9453	33.92555572
27	1	1.99949	1.98251	1.98251	1.98252	34.6561297
27	3	1.99949	1.98275	1.98277	1.98275	34.66091107
27	5	1.99949	1.9839	1.9839	1.98395	34.68370586
27	7	1.99949	1.98271	1.98271	1.98271	34.65999408
27	9	NaN	NaN	NaN	NaN	NaN
27	11	1.99949	1.96201	1.962	1.96202	34.25362734
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28	3	NaN	NaN	NaN	NaN	NaN
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28	7	NaN	NaN	NaN	NaN	NaN
28	9	NaN	NaN	NaN	NaN	NaN
28	11	NaN	NaN	NaN	NaN	NaN
29	1	NaN	NaN	NaN	NaN	NaN
29	3	NaN	NaN	NaN	NaN	NaN
29	5	NaN	NaN	NaN	NaN	NaN
29	7	NaN	NaN	NaN	NaN	NaN
29	9	NaN	NaN	NaN	NaN	NaN
29	11	NaN	NaN	NaN	NaN	NaN
30	1	NaN	NaN	NaN	NaN	NaN
30	3	NaN	NaN	NaN	NaN	NaN
30	5	NaN	NaN	NaN	NaN	NaN
30	7	NaN	NaN	NaN	NaN	NaN
30	9	NaN	NaN	NaN	NaN	NaN
30	11	NaN	NaN	NaN	NaN	NaN
31	1	NaN	NaN	NaN	NaN	NaN
31	3	NaN	NaN	NaN	NaN	NaN
31	5	NaN	NaN	NaN	NaN	NaN
31	7	NaN	NaN	NaN	NaN	NaN
31	9	NaN	NaN	NaN	NaN	NaN
31	11	NaN	NaN	NaN	NaN	NaN
32	1	NaN	NaN	NaN	NaN	NaN
32	3	NaN	NaN	NaN	NaN	NaN
32	5	NaN	NaN	NaN	NaN	NaN
32	7	NaN	NaN	NaN	NaN	NaN

Ben Ward

4. LADCP

4.1. Introduction

Cruise JR193 used two RDI Workhorse WH300 ADCP (WH) units to collect direct current velocity (LADCP) data during CTD casts. A single 300 kHz RDI WH unit (serial number 1855) was initially fixed in a downward-facing position mounted off-centre at the bottom of the CTD frame. A second WH unit (serial number 4908) was initially attached in an upward-facing position on the side of the CTD. A fin was added to the CTD frame to reduce rotation of the package. Due to communication problems with the 1855WH, the positions were swapped between casts 7 and 8 to prioritise downward data.

For the first seven stations, the LADCP was deployed as in the previous cruises (see Stansfield and Meredith, 2008, Shreeve 2006). Between stations, each ADCP was connected to a controlling PC in the Underway Instrument Control (UIC) room through a serial cable for delivery of pre-deployment instructions and post-deployment data retrieval. The battery package was recharged after each deployment, by connection to a charging unit via a power lead.

Instructions are given below for LADCP deployment and recovery during JR193. This set of instructions is based on the LADCP section of previous NOC cruise reports (including JR139 Stansfield and Meredith, 2008).

4.2. LADCP Deployment

Connect the communications and battery leads for both instruments.

Go to the controlling PC:

A) MASTER (downward looking workhorse DWH)

1. Open BBTALK window for COM1
Press <F3> to create log file for all output: filename of the form **c:\ladcp\jr193\log_files\WHM####m.txt**, where #### is CTD cast number, and *m* refers to master status
2. Press <END> or click on the blue 'B' (break) to wake up DWH if it has powered down
3. Type **TS? <ENTER>** to check DWH clock against scientific clock gives time in form YYMMDDhhmmss
Type **TS YY/MM/DD, hh:mm:ss <ENTER>** if required to reset DWH clock
4. Type **RS? <ENTER>** to check available memory of DWH
If you need to clear memory, type **RE ErAsE <ENTER>**
Only clear if backed up to UNIX drive and data processed to check they are not corrupted – all files erased

5. Type **PA <ENTER>** to run diagnostic checks. Due to the instruments being in air, some of these are likely to fail and deployment is likely to be successful despite this. Transmit nearly always returned a fail.
6. If batteries were recharged, switch off battery charge unit and check battery voltage.

The master unit is now ready to be deployed but the slave should be started first to ensure pings start at the same time.

B) SLAVE (upward looking workhorse UWH)

Repeat steps 1 - 6 in adjacent window noting:

1. UWH log file should be called **c:\ladcp\jr193\log_files\WHS###s.txt** (s refers to slave)
7. Press **<F2>** Select slave UWH configuration file – slave now ready to be told to ping by the master

Master (again)

7. Press **<F2>** select DWH master configuration file – both instruments should start pinging.

Both

8. Press **<F3>** to stop log file

Detach communication and charger cables and fit blanks to cable ends. Ensure blanks have sufficient silicon grease to make a complete seal.

4.3. LADCP Recovery

Remove blanks and attach communications and charger cables.

1. Open BBTALK COM1 window (for master) and COM2 window (for slave)
Press **<END>** or click 'B' (break) in the master window first and then the slave – both instruments then stop at the same time.
2. Check battery voltage and switch on charger if needed.
3. type **RA? <ENTER>** to check number of deployments
Reset Baud rate to 115200 to allow for faster recovery of the data by typing **CB811**
To transfer data to PC:
Go to FILE, RECOVER RECORDER
Select c:\ladcp\jr193\master\ for DWH and c:\ladcp\jr193\slave for UWH as destination files
Reset Baud rate by typing **CB411**
Type **CZ <ENTER>** once data are transferred to power down LADCPs
4. Rename the default filenames to
c:\ladcp\jr193\master\jr193M###.000 and
c:\ladcp\jr193\slave\jr193S###.000

4.4. LADCP problems

On two casts, the master returned with file sizes too small for the cast. The exact reason for this is not known but behaviour returned to normal on the following cast each time. Problems were however encountered communicating with the instruments, especially with instrument 1855 (initially downward-looking). On several occasions after a cast the baud rate was changed to 115200, but after that the instrument would not recognise further keyboard input. Communication was recovered by repeated attempts to communicate, and once re-established, the baud rate was lowered. This led to some closely spaced CTD casts at the beginning of the section not having either upward or downward looking units or having both units running. As the unit initially facing downward was the first (and always the main) one to have problems, the units were switched on the CTD frame, to prioritise collecting downward data. This led to a complete set of downward data after the initial problems, except for cast 21, when the file size was too small.

A further problem was that once connected after a cast the units occasionally self-deployed rather than powering down (the reason for this was not worked out). When this happened, selecting the main cast file sometimes resulted in the short self-deployed deck run file being downloaded instead. The only solution found to this was to select files and download the entire transect at the end (this takes several hours so can't be done during the transect).

Slave (upward-looking, with downward data) casts: 2-6, 11, 12, 13, 15-41

Master (downward-looking) casts: 1, 3-6, 8, 11-32, 33-41 (casts 2, 6, and 21 failed to record downward data).

Upward-looking data only (as set up prior to deployment): 7

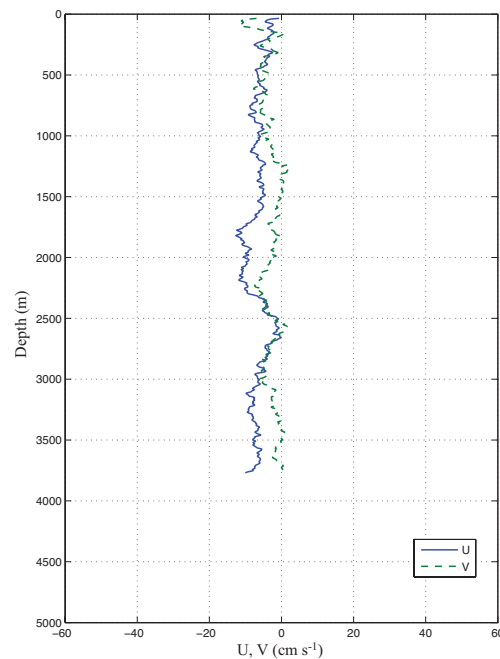


Figure 10: Example of derived vertical velocity profile (station 22 downcast).

Hugh Venables & Gerard McCarthy

5. VMADCP

5.1. Introduction

A 75 kHz RD Instruments Ocean Surveyor (OS75) ADCP was used during this cruise similar to JR139 (Stansfield and Meredith, 2008) and JR161 (Shreeve, 2006). The OS75 is, in principle, capable of profiling to deeper levels in the water column than the previous 150 kHz ADCP and can also be configured to run in either narrowband or broadband modes.

5.2. Instrument and configuration

The OS75 unit is sited in the transducer well in the hull of the RRS *James Clark Ross*. This is flooded with a mixture of 90% de-ionised water and 10% monopropylene glycol. With the previous 150 kHz unit, the use of a mixture of water/anti-freeze in the transducer chest required a post-processing correction to the derived ADCP velocities. However, the OS75 unit uses a phased-array transducer that produces all four beams at specific angles from a single aperture. A consequence of the way the beams are formed is that horizontal velocities derived using this instrument are independent of the speed of sound within this mixture (vertical velocities, on the other hand, are not), hence this correction is no longer required.

The OS75 transducer on the RRS *James Clark Ross* is aligned at approximately 60 degrees relative to the centre line. This differs from the recommended 45 degrees. After sailing for JR139, the hull depth was measured by Robert Patterson (Chief Officer), and found to be 6.47m. Combined with a value for the distance of the transducer behind the sea-chest window of 100-200 mm and a window thickness of 50 mm, this implies a transducer depth of 6.3 m. This is the value assumed for JR193, but note that the ship was very heavily laden during cruise JR139, and for other cruises it may be shallower.

During an earlier cruise, it was noted that the OS75 caused interference with most of the other acoustic instruments on RRS *James Clark Ross*, including the EM120 swath bathymetry system. To circumvent this, the ADCP pinging was synchronised with the other acoustic instruments using the Sounder Synchronization Unit (SSU), however, this reduces the ping-rate. As noted by Dr. Sophie Fielding, when in deep water the swath can take 20 to 30 seconds from ping to end of listening, as a result this means the ADCP only pings once every 25 or so seconds. A further problem that was previously encountered is that the ADCP appears to "time out" every other ping when it has to wait a long time between pings (i.e. when running in deep water alongside the EM120). This results in it rebooting and waking the ADCP instrument up every other ping, which simply exacerbates the problem. A fix is promised by BAS AME, but requires a firmware upgrade from RDI, which is not presently available. (This is an issue that has been outstanding for many years.) To circumvent these problems, only the single-beam echosounder (EA600) was run alongside the OS75 during JR139. This was again the case for JR193 though the swath was used after the Drake Passage section in parallel with the ADCP with no obvious problems, although the swath data have not been analysed fully (it was used to give depth information across a wider area while taking a new course).

The heading feed to the OS75 is the heading from the Seapath GPS unit. This differs from the previous ADCP setup on the RRS *James Clark Ross*, which took a heading feed from the ships' gyrocompass and required correction to GPS heading (from Ashtech) in post-processing.

The OS75 was controlled using Version 1.42 of the RDI VmDas software. The logging PC also had Version 1.13 of the RDI WinADCP software installed and running, to act as a real-time monitor of data. This was not run in the first half of JR193 and the only real-time monitoring of the data came from an hourly logging of the ensemble number, an hourly check on the navigation stream and a 12-hourly run through of the data using a Matlab routine. The WinADCP software was used later in the cruise. The loss of data that occurred before the Burdwood Bank (see Section 5.5) might have been flagged earlier, had the WinADCP software been running. The OS75 ran in two modes during JR193: narrowband with either bottom tracking on or off. In both cases, profiling was with sixty-five 16m bins, which has been hardwired by Hugh Venables into the Matlab code used for analysis, as this makes it easier for the Matlab scripts to concatenate the arrays when processing multiple files. Profiling was set up with an 8 m blanking distance. (Note that this blanking distance is larger than the 2m initially used by the RDI technician during the trials cruise. This change was adopted following advice from Dr. Mark Inall and Dr. Deb Shoosmith, who voiced concerns over the quality of data in the top bin). The time between pings was set to 2 seconds, again following advice from Dr. E. Hawker and Dr. Deb Shoosmith. Salinity at the transducer was set to zero, and Beam 3 misalignment was set to 60.08 degrees.

5.3. Output Formats

The ADCP writes files to a network drive that is samba-mounted from the Unix system. (Should the network fail, there is an alternative write path to the local ADCP PC hard drive to preserve data until the link is restored). For use in the Matlab scripts the raw data saved to the PC have to be run through the VMDas software again to create the .ENX files from the .ENR and .N1R files. When the Unix system is accessed (via samba) from a separate networked PC, this enables post-processing of the data without the need to move files.

Output files are of the form JR193_XXX_YYYYYY.ZZZ, where XXX increments each time the logging is stopped and restarted, and YYYYYY increments each time the present file size exceeds 10Mb.

ZZZ are the filename extensions, and are of the form:

- .N1R (NMEA telegram + ADCP timestamp; ASCII)
- .ENR (Beam coordinate single-ping data; binary)
- .VMO (VmDas configuration; ASCII)
- .NMS (Navigation and attitude; binary)
- .ENS (Beam coordinate single-ping data + NMEA data; binary)
- .LOG (Log of ADCP communication and VmDas error; ASCII)
- .ENX (Earth coordinate single-ping data; binary)
- .STA (Earth coordinate short-term averaged data; binary)
- .LTA (Earth coordinate long-term averaged data; binary)

5.4. Post-processing of Data

OS75 data were processed on JR193 using Matlab code originated by IFM Kiel. This was adapted by Dr. Mark Inall, Dr. Deb Shoosmith, Angelika Renner, Mark Brandon and Hugh Venables for use with the system on board the RRS *James Clark Ross*. The master file for the processing is “*OS75_JCR_jr193.m*”, which calls a lengthy sequence of routines to execute the following steps:

- 1) Read RDI binary file with extension .ENX and ASCII file with extension .N1R into Matlab environment.
- 2) Remove missing data and data with bad navigation.
- 3) Merge Seapath attitude data with single-ping ADCP data.
- 4) Correct for transducer misalignment and velocity scaling error (calculated during first run-through of code, applied during second).
- 5) Derive ship velocity from Seapath navigation data.
- 6) Perform quality control on data, such that only the four-beam solution is permitted. Other screening is performed based on maximum heading change between pings, maximum velocity change between pings, and the error velocity.
- 7) Average data into ensembles of pre-defined length (120 seconds for JR193)*.
- 8) Calculate transducer misalignment and velocity scaling error (computation done on first run-through of code, to be applied during second).
- 9) Set to missing any velocities from depths deeper than 86% of the bottom-tracking depth.
- 10) Determine absolute velocities from either bottom-track ship velocity or Seapath GPS (usually the latter).

*- The function *average_pings.m* was modified for this cruise from that used during and after JR165. The main change was the introduction of an *istart* variable that is passed between loops via the main *OS75_JCR_jr193.m* program. This and some other small changes ensure that the arrays of data have a one-entry-per-time interval structure. The averaging over pings has also been changed to solve a bug with overlapping intervals and also to avoid the script averaging over the wrong array dimension – previously caused by there being none or one ping in a time interval. The result was to average day of year, latitude and longitude. Both these issues can be checked by the plot of time against array dimension that has been added – all points should lie on a straight line. Separately, following processing of JR161 data the *OS75_JCR_jr193.m* program was modified to only call *average_pings* if navigation (time) data were present as otherwise the function crashed the processing. However, there were no problems of absent navigation data during JR193.

5.4.1. Output Files

Final data are stored in Matlab format. Filenames are of the form:

- 1) JR193_00A_00000B_raw.mat, where A is the highest number of the user-incremented files. This is the number that VmDas increments every time logging is stopped and restarted. The version number is B. B is the number VmDas increments every time filesize exceeds 10 Mbyte.
- 2) JR193_00A_00000B_att.mat, this contains the ships’ attitude data.

- 3) JR193_00A_00000B_sgl_ping.mat.
- 4) JR193_00A_00000B_bad_heading.mat.
- 5) JR193_00A_00000B_bad_nav.mat.

5.5. JR193 data

The data were collected in a series of files for the section, due to the required changes in configuration file when the VMADCP needed to be changed from bottom-tracking to normal mode, and also to allow regular (12-hourly) processing of the data during the cruise.

There were few issues with the data collection during the section. Some data were lost north of the Burdwood Bank (from approximately 04.00 - 09.00 on day of year 334/30th November). The ADCP had been running in bottom-track mode and it is believed that the sharp increase in depth before the bank led to the instrument timing out and losing data. Another brief gap existed when the instrument was briefly turned off on station 5, so as not to interfere with other acoustic equipment being used by scientists from the Proudman Laboratory to track a deployed lander. This loss was only while on station and does not affect latitude plots of the data.

5.5.1. Results

A latitude plot of the zonal and meridional velocity fields (Figure 11) clearly shows the Subantarctic Front as a strong eastward flow centred near 55.7° S. The Polar Front is visible further south around 56.6° S. After crossing the Shackleton Fracture Zone (60°S) some reversal in the zonal flow is seen. This corresponds to a change in the meridional velocity field. These features are eddy-like where the ACC retroflects on itself. A similar plot was produced for the Marguerite Bay section (Figure 12). This time the velocity field is plotted against distance travelled as the section is not as distinctly a north-south transect.

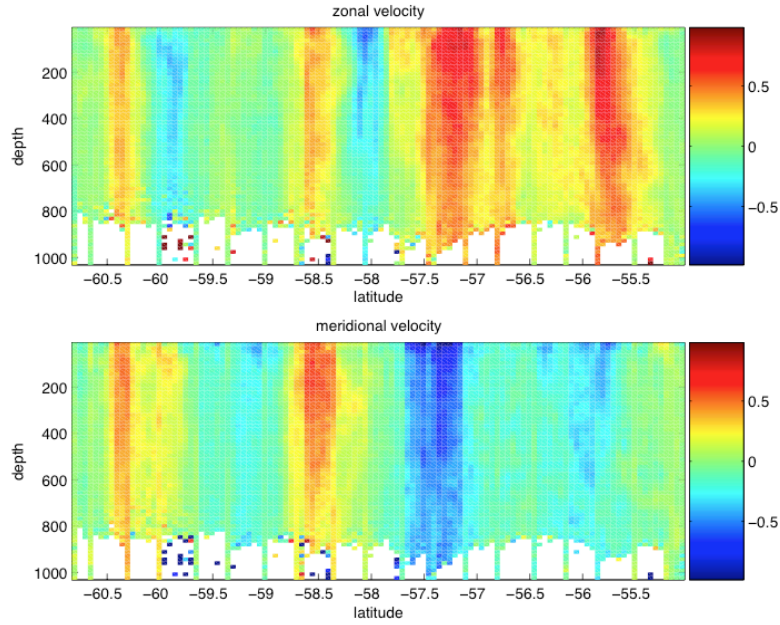


Figure 11: Zonal (top) and meridional (bottom) sections of VMADCP currents across Drake Passage during JR193 (2007, Day of year 335-338). The data are binned into 0.05° of latitude.

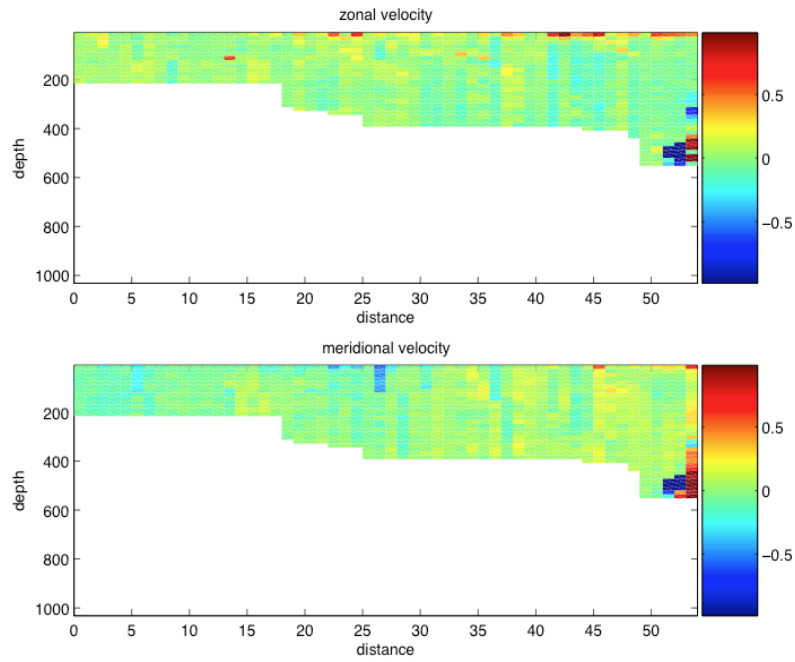


Figure 12: Zonal (top) and meridional (bottom) sections of VMADCP currents across Marguerite Trough during JR171 (2007, Day of year 341-342). The data are binned into 1.5 km segments along the section. There appear to be some difficulties in interpretation of these data, as the inferred bottom does not match the bathymetry (Figure 26); caution is thus required in using ADCP data in such shallow waters.

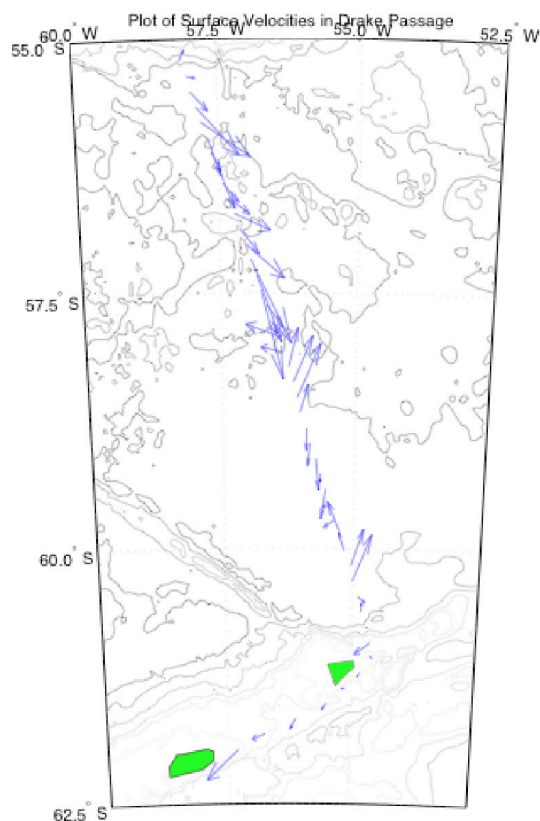


Figure 13: Surface velocity averaged over the first three bins (depths 8-56m) for section across Drake Passage.

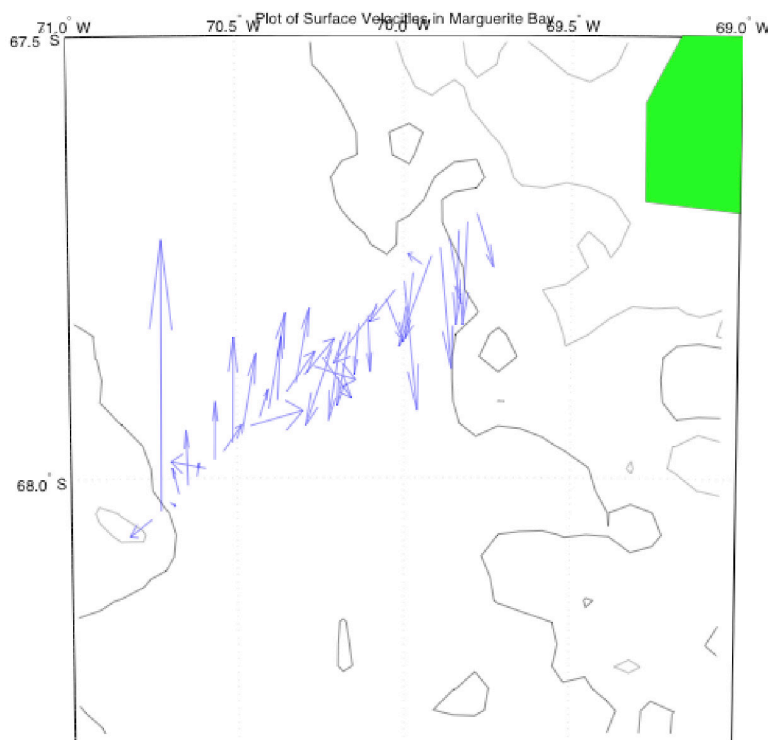


Figure 14: Surface velocity averaged over the first three bins (depths 8-56m) for section across Marguerite Trough. The large northward velocity in the west of the diagram corresponds to the spurious values also seen towards the end of the section in the cross sectional plot (Figure 12).

5.5.2. Error analysis

The VMADCP was run in bottom-track mode after the Drake Passage section. It ran alongside the TOPAZ (EA120) swath bathymetry system from Elephant Island to Damoy as a new track was being followed. Data were recorded and no significant interference was noted.

Post-processing of the data to discern the misalignment angle and the misalignment amplitude was performed. Water-track data were surprisingly found to give a more consistent answer. Consistency here means that the spread of the angle and amplitude was roughly normally distributed. This may also be related to the fact that there were more data in this section and that the median value closely corresponded with the mean values for both misalignment angle and amplitude. This was not the case for bottom-track data. The misalignment statistics are used to negate any horizontal striping between stationary and moving segments. It was found that the misalignment amplitude was more important than the misalignment angle in reducing this striping. The amplitude correction is applied before ship speed is removed so it has most effect on data in the direction of ship movement. For velocities in the direction of ship movement, misalignment angle has a negligible effect compared with amplitude errors, even for very large misalignment. Figure 15 shows analysis of 4 days. This corresponds to the majority of the time that the instrument was set to water track over the course of the Drake Passage section. Bottom-track data were available from the beginning of the cruise until after the Burdwood Bank and again after the Drake Passage section while cruising down the Antarctic Peninsula. This is shown in Figure 16. A summary of the results of both analyses is given in Table 4.

Table 4: Corrections obtained from analysis of water-track and bottom-track modes.

	Mean (S.D.)	Median
Water-track: A - Amplitude	1.0101 (0.007)	1.0102
Water Track: a - Angle	-0.0542° (0.364°)	-0.0594°
Bottom-track: A – Amplitude	1.0118 (0.010)	1.0114
Bottom-track: a - Angle	-0.2018° (1.008°)	-0.0594°

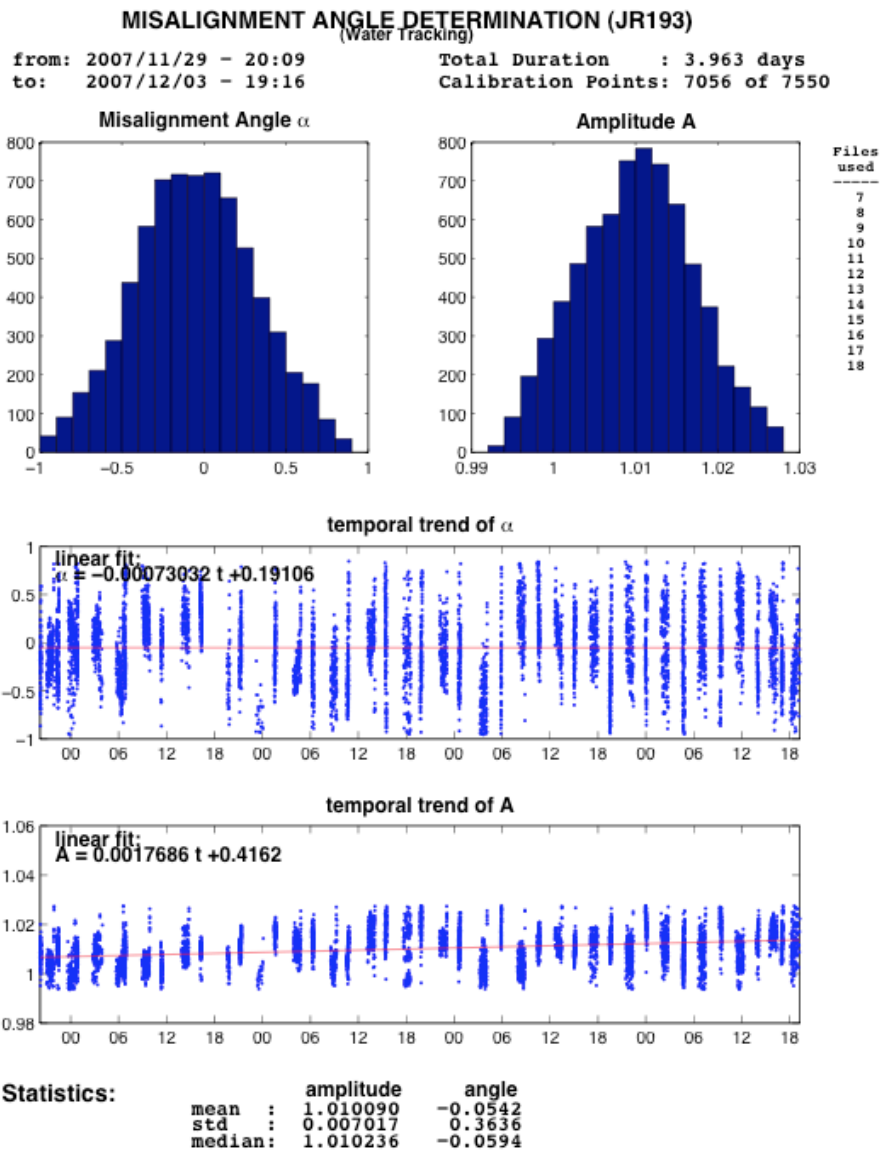


Figure 15: Misalignment angle and amplitude from water-track data. Note the near-normal distribution of both the angle and amplitude. This fact is reinforced by the near coincidence of mean and median.

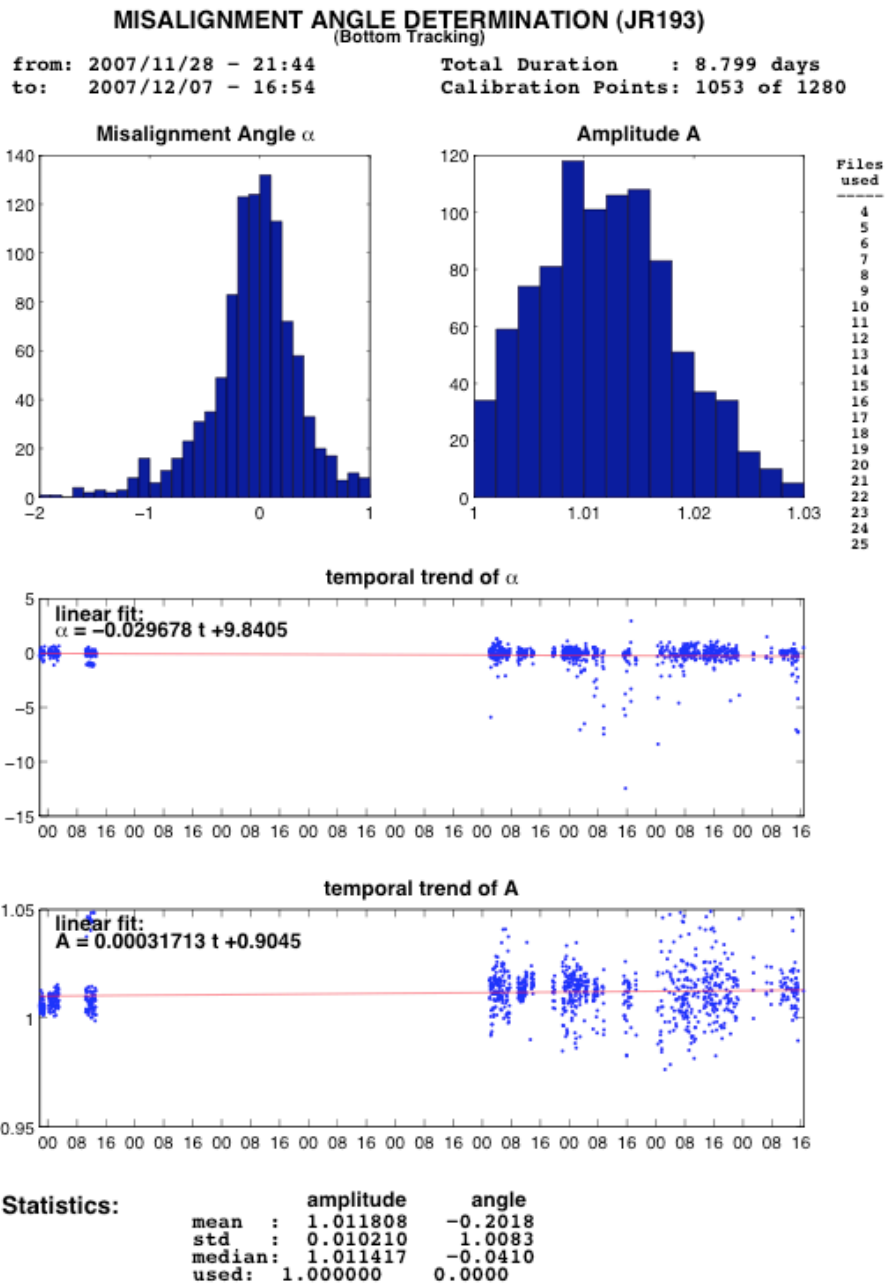


Figure 16: Misalignment angle and amplitude from bottom-track data. Note that the distributions are not normal. This is evidenced by the disagreement between mean and median especially for misalignment angle. Note the large gap in data corresponds to the duration of the Drake Passage section when water tracking was enabled and no bottom track data were available.

The software is designed such that the misalignment statistics are calculated on the first run and then these are used in a final run of the data. It is noted in the software that the negative of the misalignment angle calculated should be used. The effect of the adjustment can be seen in Figure 17.

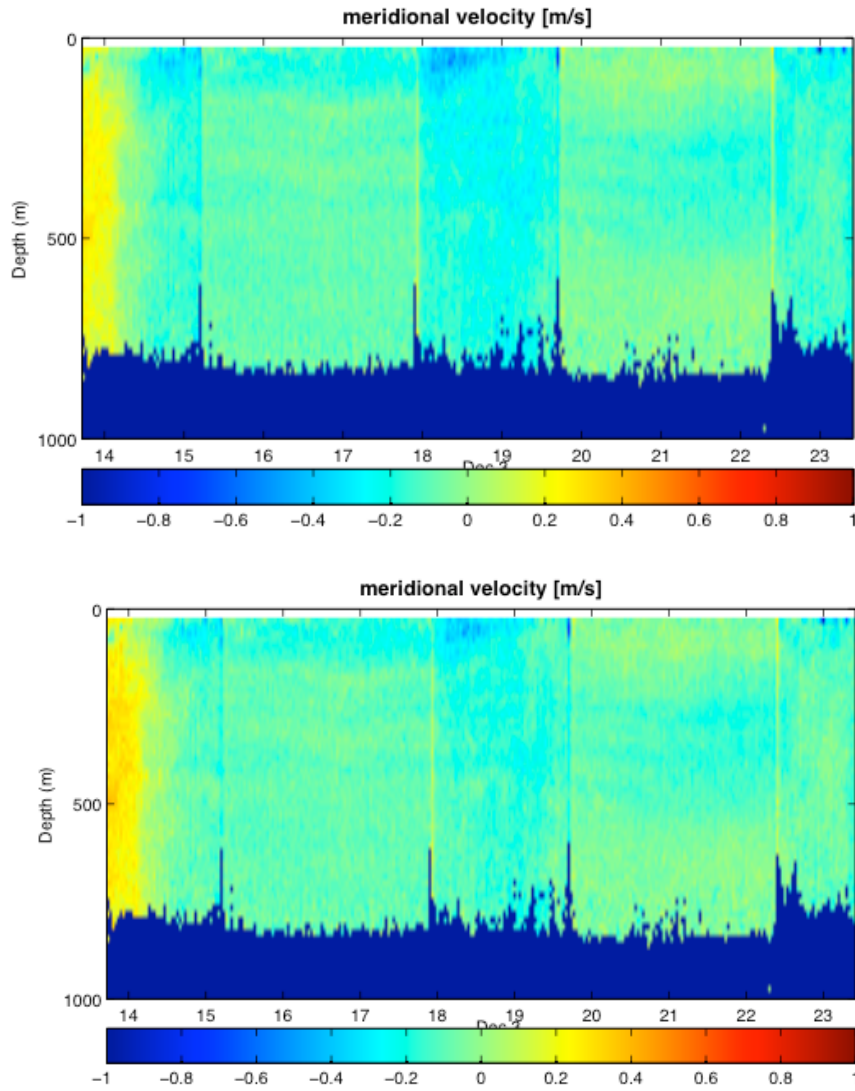


Figure 17: Meridional velocities as a function of time. The top figure shows the sort of striping that arises on and off station, due to changes in speed and orientation of the ship. The bottom figure shows a reasonable reduction in this artefact after the adjustment for misalignment angle and amplitude.

5.5.3. Spurious Feature

A distinct shallow feature was noticed within the data whilst on station, which was characterised by a locally increased current on the downcast and a decrease on the upcast. This feature is highlighted in Figure 18. It is more noticeable in the zonal velocity plot than in the meridional velocity. This feature was attributed to the cable of the CTD being veered and hauled.

The instrument documentation stated that the beam angle was 30° and that the instrument was mounted 23 m from the location of the CTD; these figures are consistent with finding a feature around a depth of 40 m (i.e. the third bin).

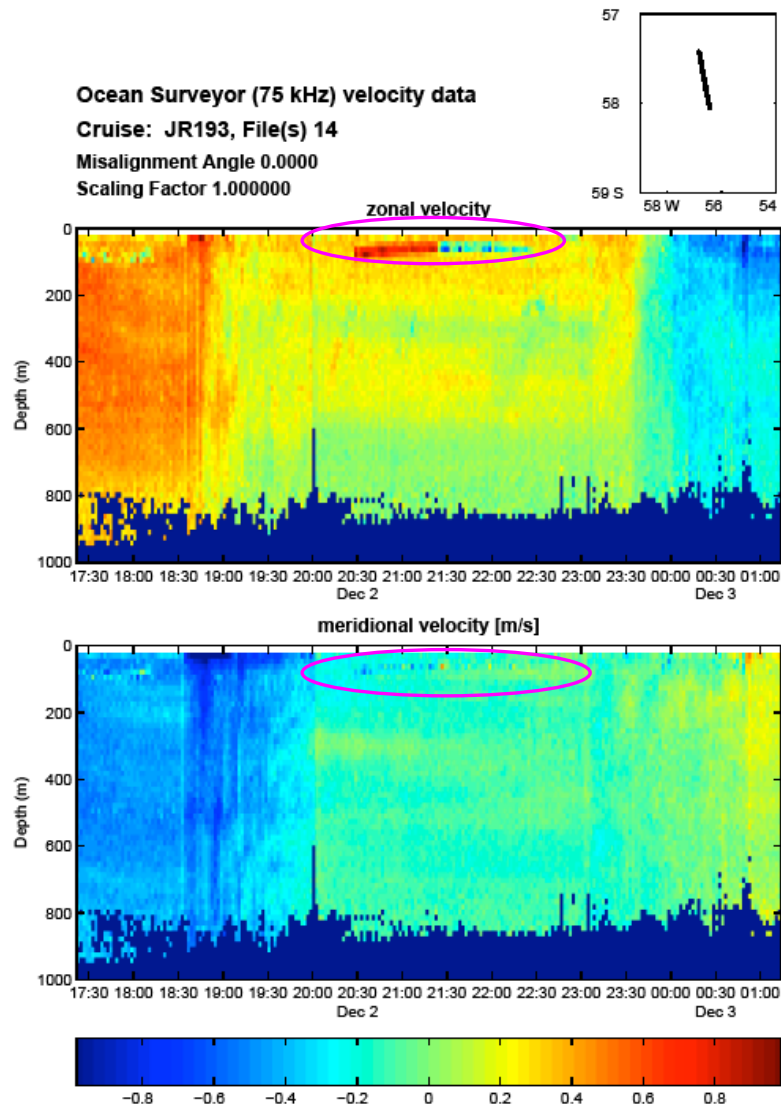


Figure 18: Ocean Surveyor (75 kHz) data as a function of time. Circled feature corresponds to time on station 18.

Gerard McCarthy & Hugh Venables

6. Underway System

6.1. Introduction

Underway data come from the meteorological sensors, situated on the forward mast, and the ocean surface layer sensors, which measure the properties of the uncontaminated water supply. The oceanographic measurements include temperature, conductivity and fluorescence. The meteorological measurements include air temperature, humidity, atmospheric pressure, total incident radiation and photosynthetically available radiation (PAR). Other parameters sampled include the temperature of the conductivity sensor and the flow rate of the uncontaminated water supply. Data from these sensors feed into the ships' oceanlogger data system. From there they are transferred to the ships' SCS scientific data collection system and hence to the UNIX and PC computer network.

Underway data first became available on 26th November 2007 (day of year 330) at 00:04 and were then collected continuously until 17:40 on day of year 342.

6.2. Data Capture and Processing

Data were processed in 24-hour sections using *pstar* whilst on board the ship. The scripts are based on those used during the previous JR94, JR115, and JR163 cruises (see Hawker et al., 2005, Sparrow and Hawker, 2005). The executables for processing the data are described below:

oclexec0: Reads the ocean-logger and anemometer data streams and stores them in a single *pstar* type file called 193oclXXXd.raw (where XXX = day of year).

oclexec1: Splits the data into separate ocean data and meteorological data files. It also performs some initial de-spiking of the conductivity data and calculates a raw salinity value. This creates a file called 193oclXXXd (and a meteorological file 193metXXXd.raw).

twvlexec: Merges the met data file with gyrocompass and navigation data streams in order to calculate ship motion and true wind velocity. Some de-spiking is also performed. This creates a file called 193metXXXd.

Data were then further de-spiked and plotted using Matlab and the differences between duplicate meteorological instruments calculated.

As of August 2010, additional processing has been performed on the meteorological and ocean underway data using the *mstar* processing suite. This suite has been used on recent cruises since JC031 (McDonagh et al. 2009), which was a Drake Passage repeat that took place in February 2009. The most recent processing that was performed using *mstar* consisted of appending the daily *met* and *ocl* files into a merged file which contains a continuous record of all the *met* and *ocl* data collected during JR193. This required a fair bit of processing of relevant *nav* data to ensure that the correct files needed to run certain scripts were present. An appended met file (*met_jr193_01.nc*) was needed, as was an appended nav

file (*bst_jr193_01.nc*), which was created from the scripts *mbest_01.m* – *mbest_04.m*. These appended files were converted into 2-minute averaged data using the function *mavrge*, which is part of the mstar suite. The start, stop and step times specified were -60, 1×10^{10} , and 120 respectively. This meant that the two-minute averages could be centred on the minute boundary, which just helped to keep the data tidy and easy to understand.

Additional processing was required for averaging the true and relative wind directions. To avoid problems associated with averaging wind direction over time, the relative wind speed, ships' heading and course made good were converted to eastward (*u*) and northward (*v*) components using the script *muvsd.m*. Initially the file *met_jr193_true.nc* was created using the script and then the subsequent averaging created a file called *met_jr193_trueav.nc*, which is a 1 minute average.

6.3. Oceanographic Parameters

Sea surface salinity (SSS) was calculated from the thermosalinograph's (TSG) measurements of conductivity and water temperature. In addition, water samples were taken every 4 hours from the ships' uncontaminated water supply.

Figures 19, 20 and 21 are constructed from underway data and from these, variations in sea surface temperature (SST), sea surface salinity (SSS), and fluorescence can be observed respectively.

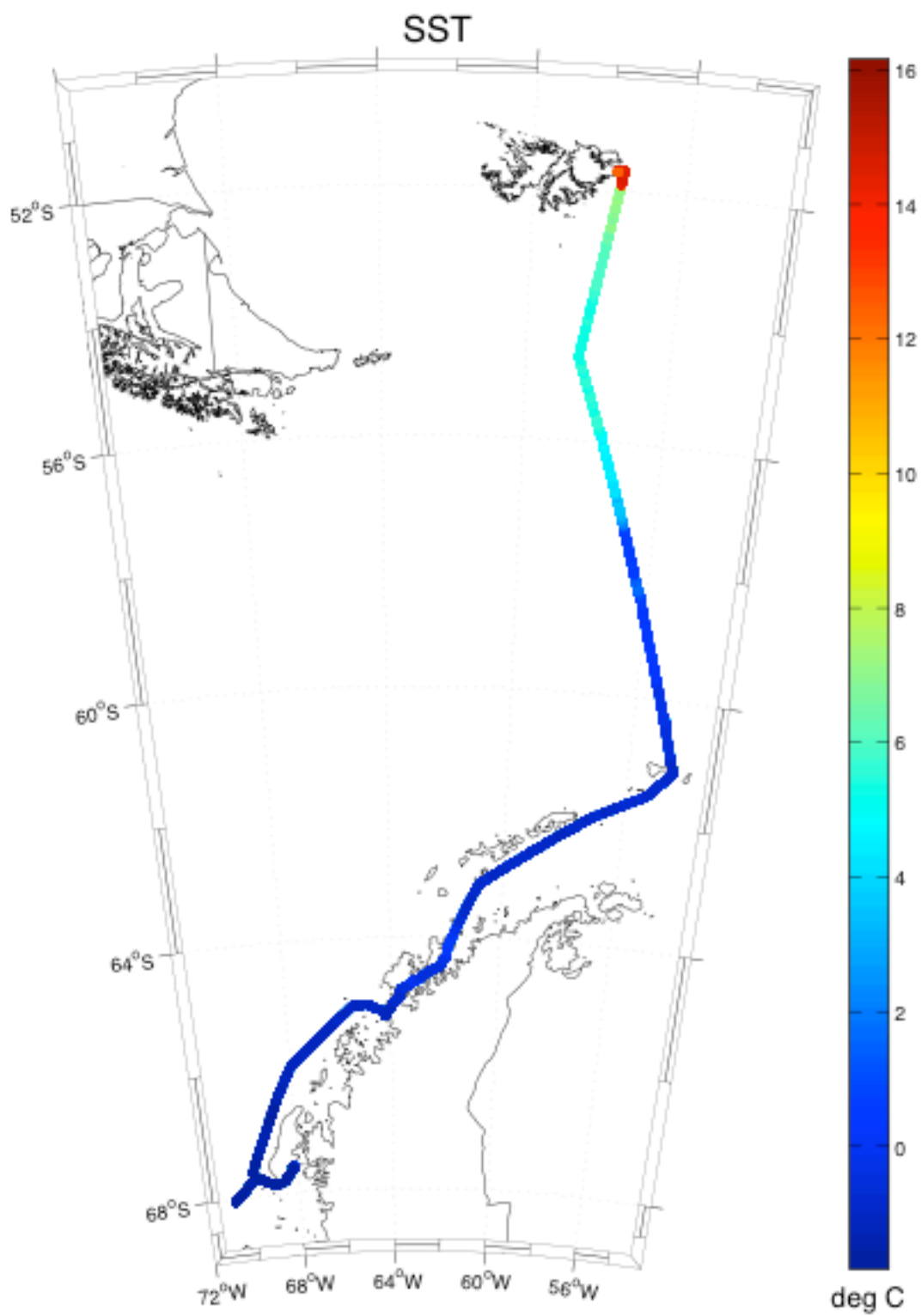


Figure 19: Sea surface temperature along the cruise track of JR193

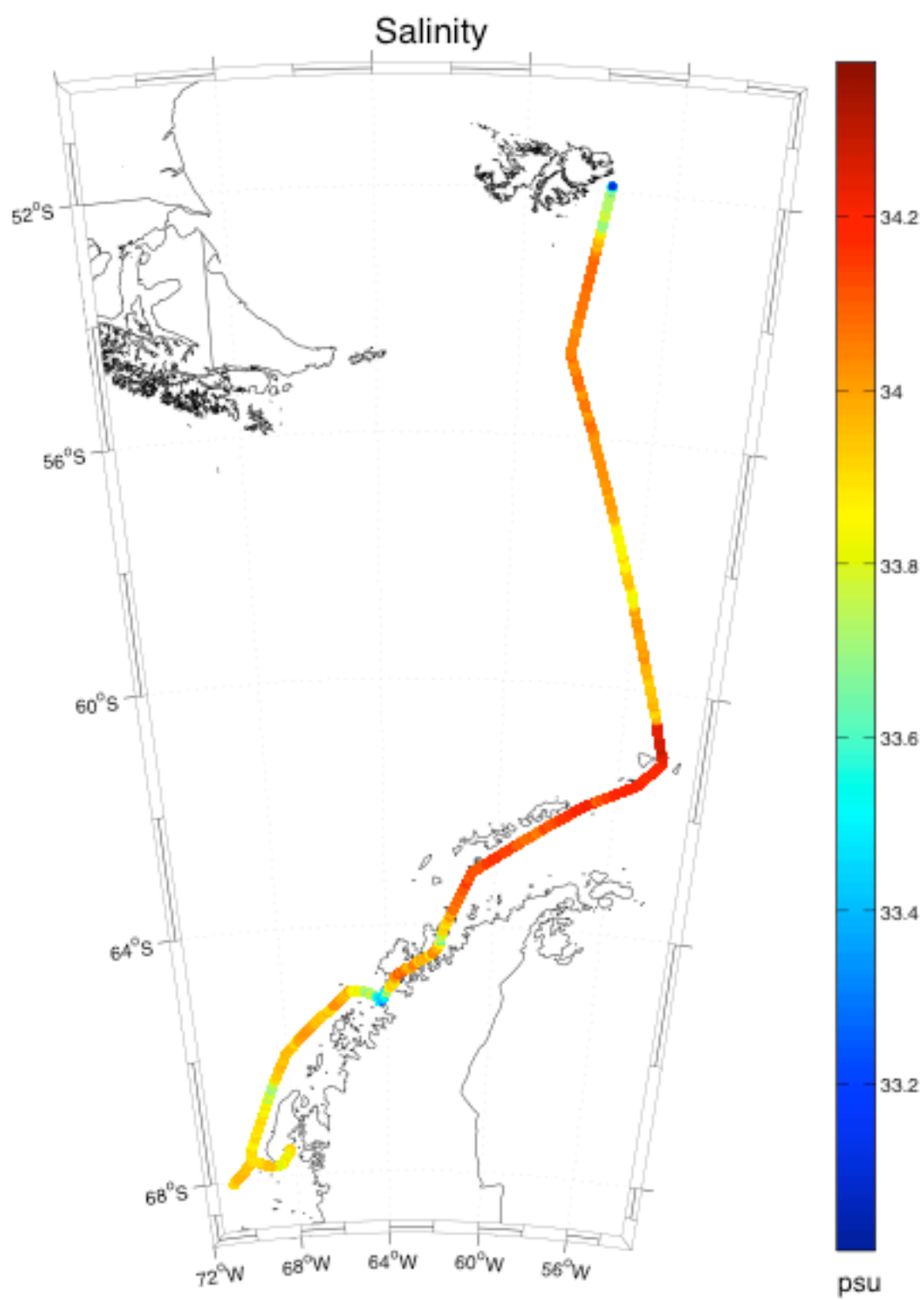


Figure 20: Sea surface salinity along the cruise track of JR193

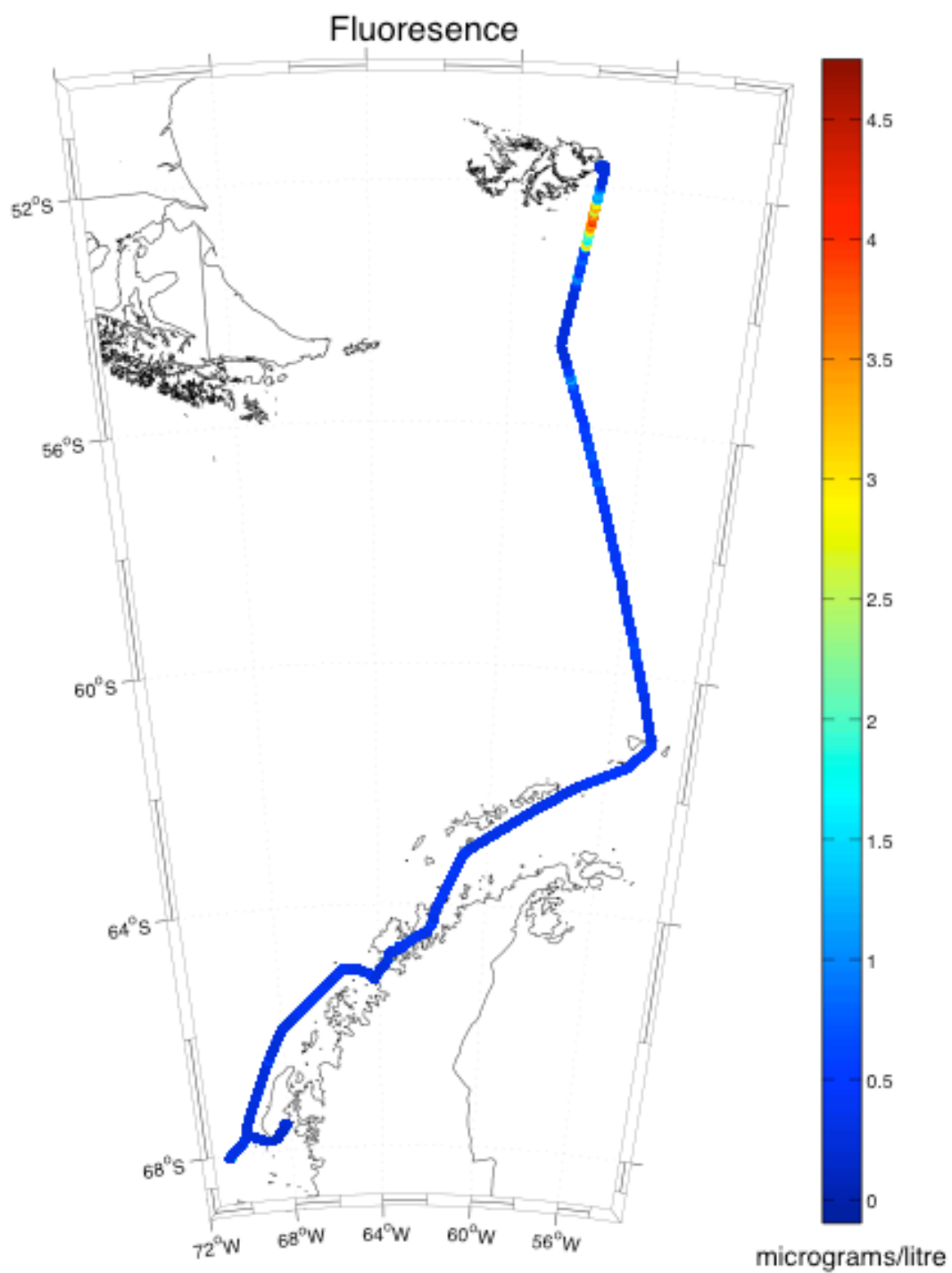


Figure 21: Fluorescence along the cruise track of JR193

6.4. Meteorological Parameters

Below are various time series of 2-minute averaged meteorological data. Only basic quality controls have been applied to these data. Each figure contains five plots showing different variables (Air temperature, sea surface temperature, wind direction, wind speed, air pressure, humidity, TIR and PAR) over a 4-day period.

A description of the figure plots follows:

- Top panel – plot of air temperature and SSTs from the oceanlogger.
- Second panel – downwelling radiation from the two shortwave TIR and PAR sensors, all in Wm^{-2} .
- Third panel – relative wind direction and true wind direction from the anemometer. The ship's true heading is also shown.
- Fourth panel – relative and true wind speeds in ms^{-1} from the anemometer.
- Bottom panel – atmospheric humidity and atmospheric pressure.

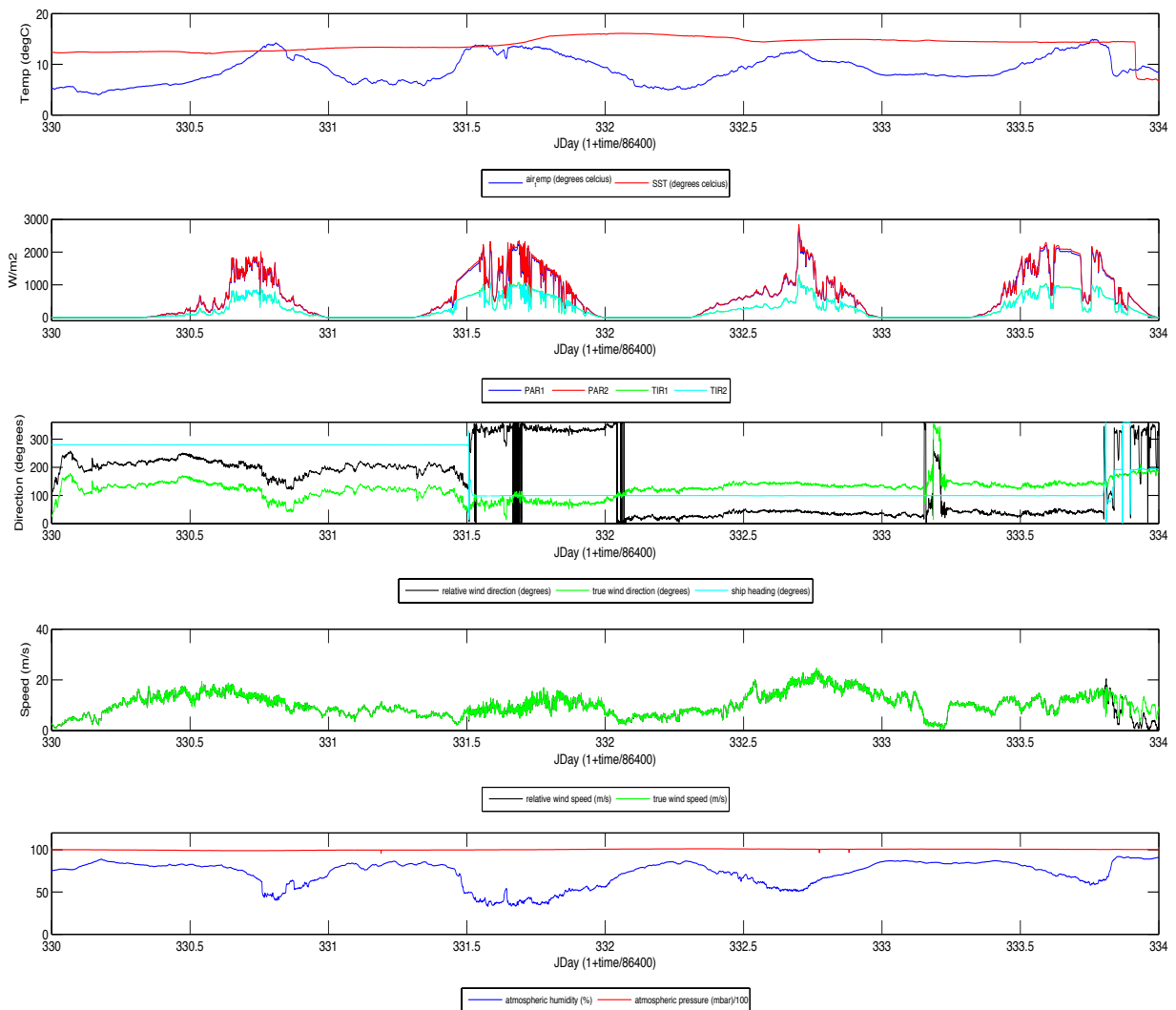


Figure 22: Meteorological data for days 330 to 334.

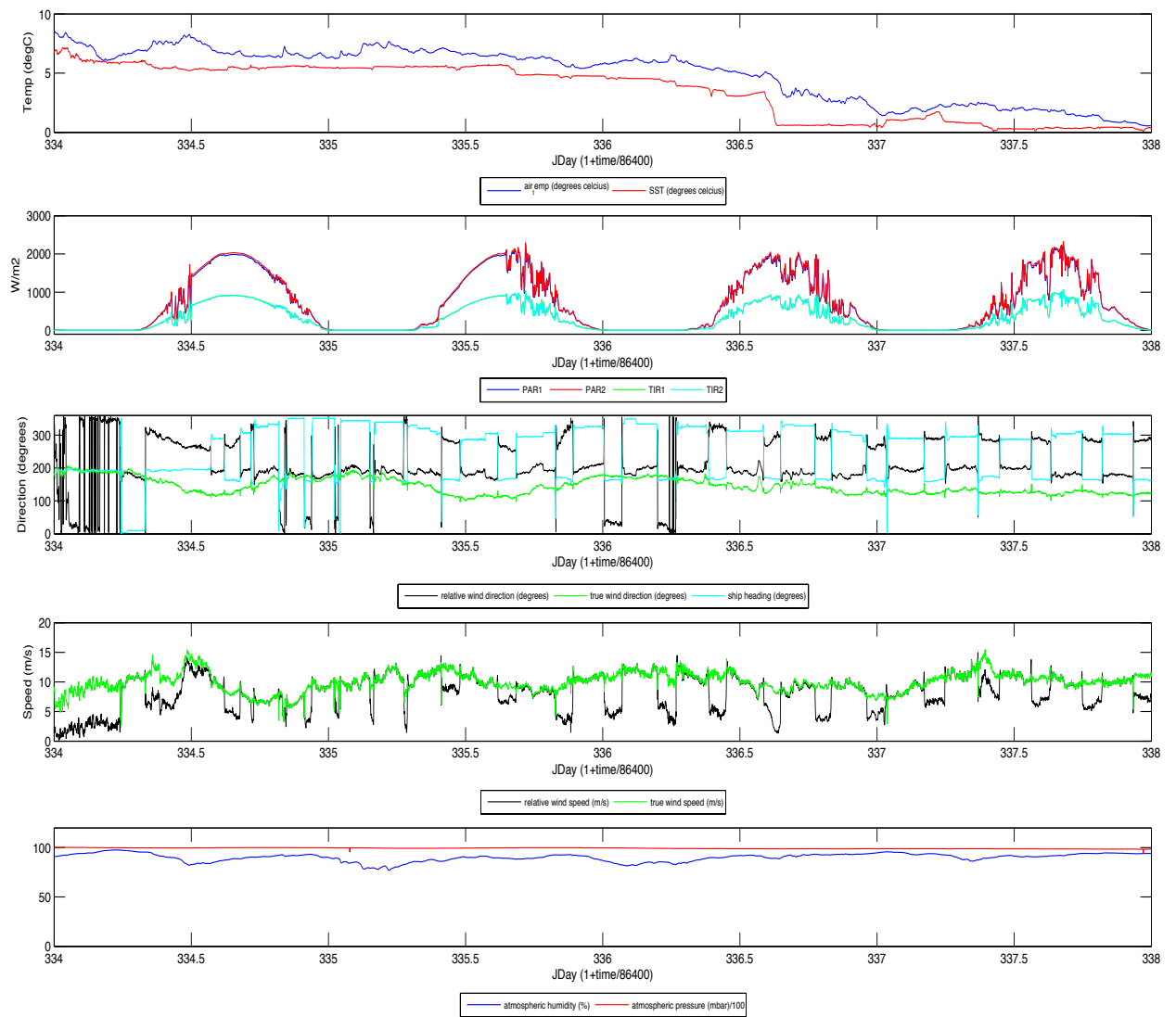


Figure 23: Meteorological data from days 334 to 338

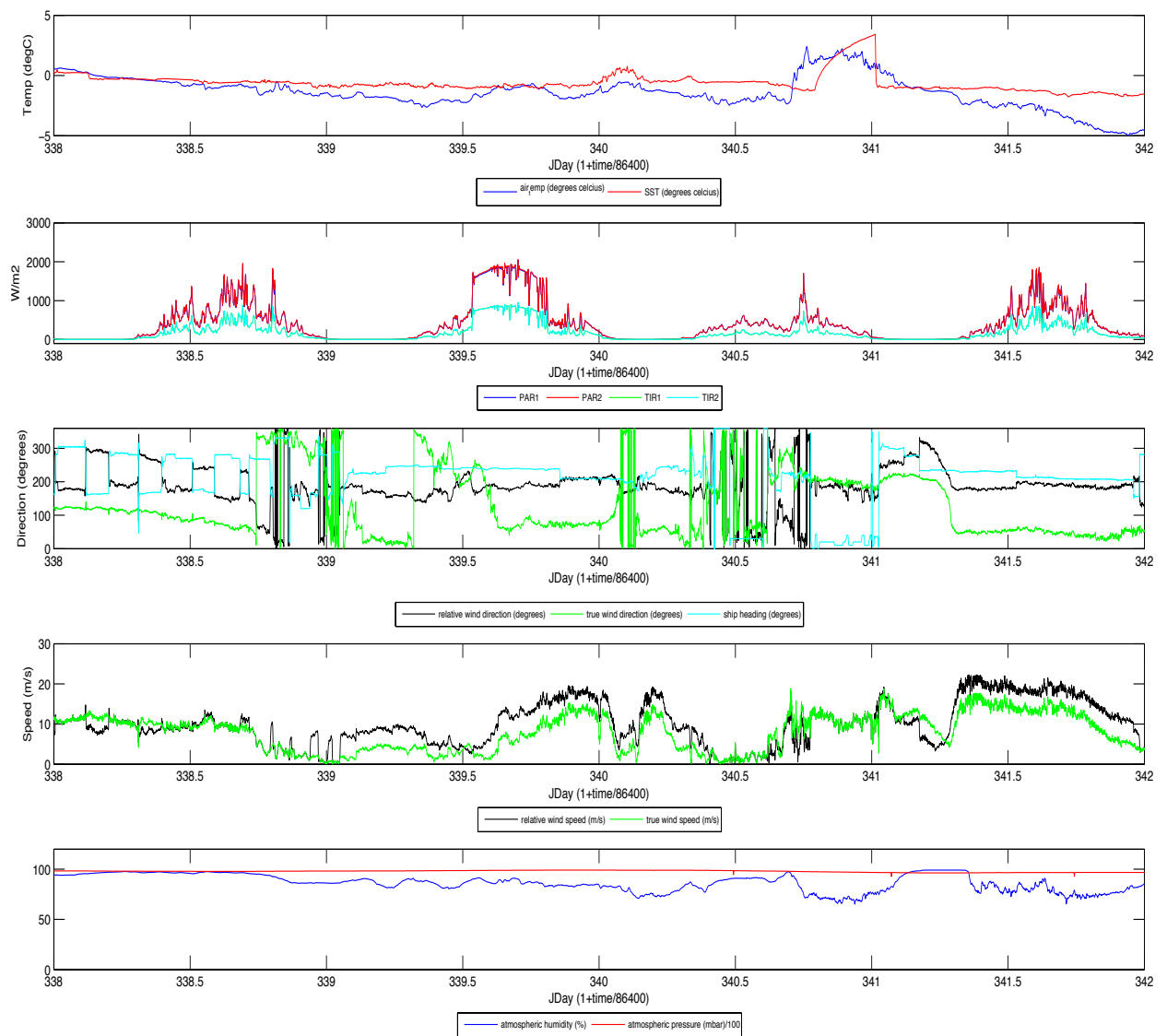


Figure 24: Meteorological data for days 338 to 342

David Hamersley

7. Echo Sounder

The main depth information came from the single beam echo sounder, EA600 made by Kongsberg. However, its data stream retains the name 'sim', after Simrad, the previous instrument. There was also a multi-beam swath system, EA120 (TOPAZ), that was running at the master's request when we were following an unsurveyed route to the south of Elephant Island. Those data are not covered here.

Data were extracted from the RVS system on a daily basis using *simexec0*, which also applies some filtering. These data have been subsequently merged with navigation data from the Ashtech and GPS data streams. The depth sections across the monitoring lines of interest are shown in Figures 25 & 26. Note, this instrument is setup with a default sound speed of 1500ms^{-1} , which is generally thought of as an underestimate; so initial estimates for CTD casts will be conservative. A comparison of EA600 estimates with bottom pressure plus altimeter reading (Figure 27) shows that the echosounder overestimates depth by about 3.5% for the stations near 68°S and also those near Elephant Island. The echo-sounder data are also compared with those extracted from the Sandwell & Smith (1997) satellite-derived database. This source has a nominal 2' resolution, and for this brief comparison the nearest point was used rather than some interpolation. Although the satellite source has most of the large-scale bathymetry correct, it is not a source that could be trusted in very shallow water, as it can be out by more than a factor of two. Also some bathymetric features have been traversed during this cruise that are not present in Sandwell & Smith data (see Figure 28c).

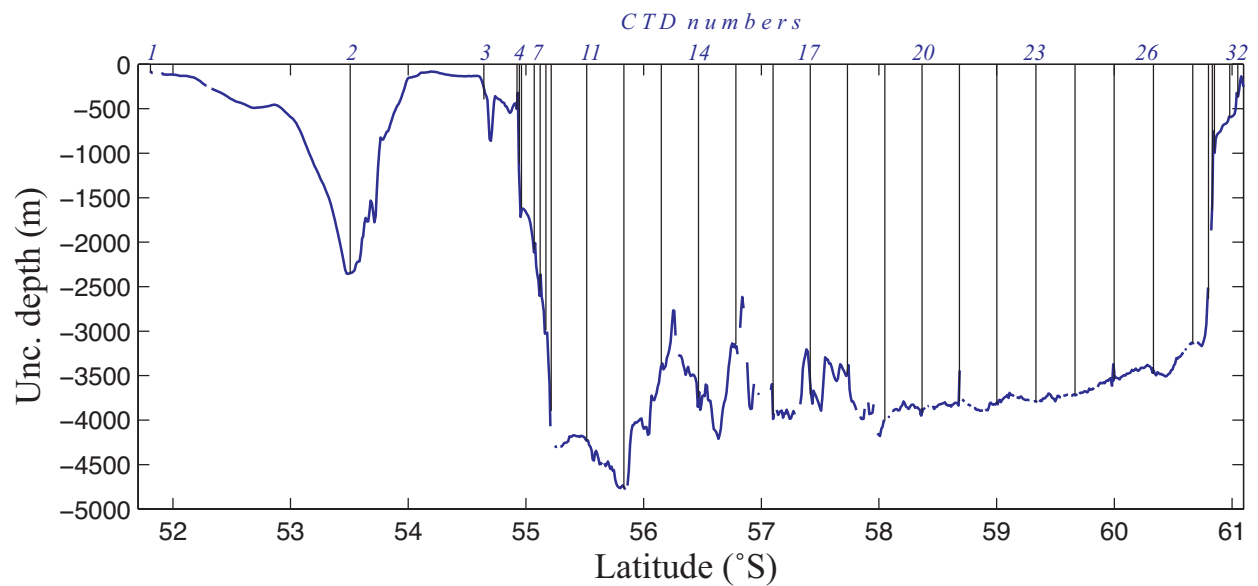


Figure 25: Initial pass of depth data for section from Stanley to Elephant Island

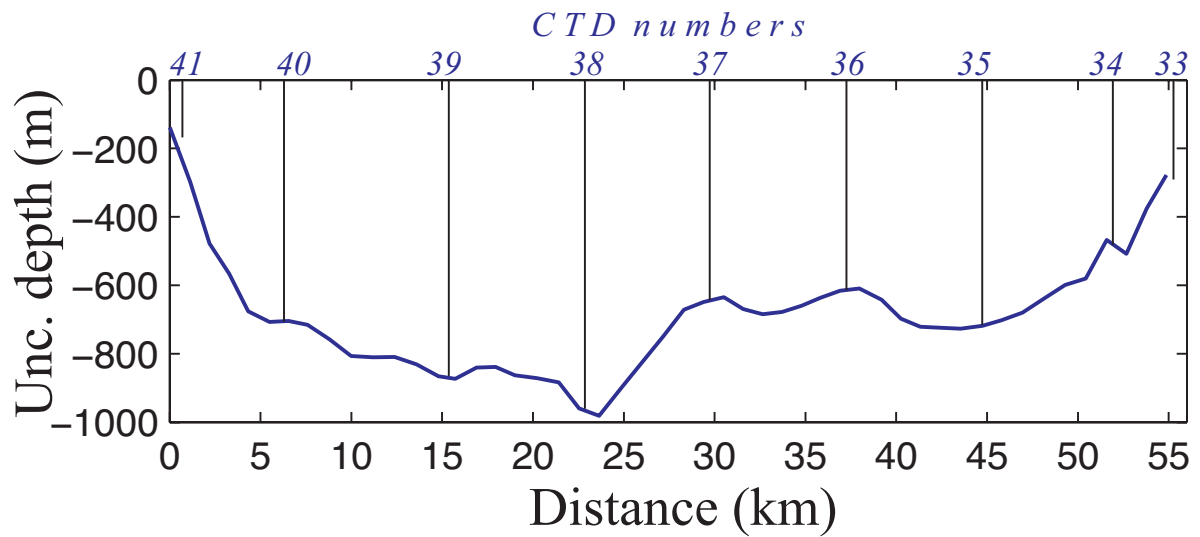


Figure 26: Initial pass of depth data for section across Marguerite Trough

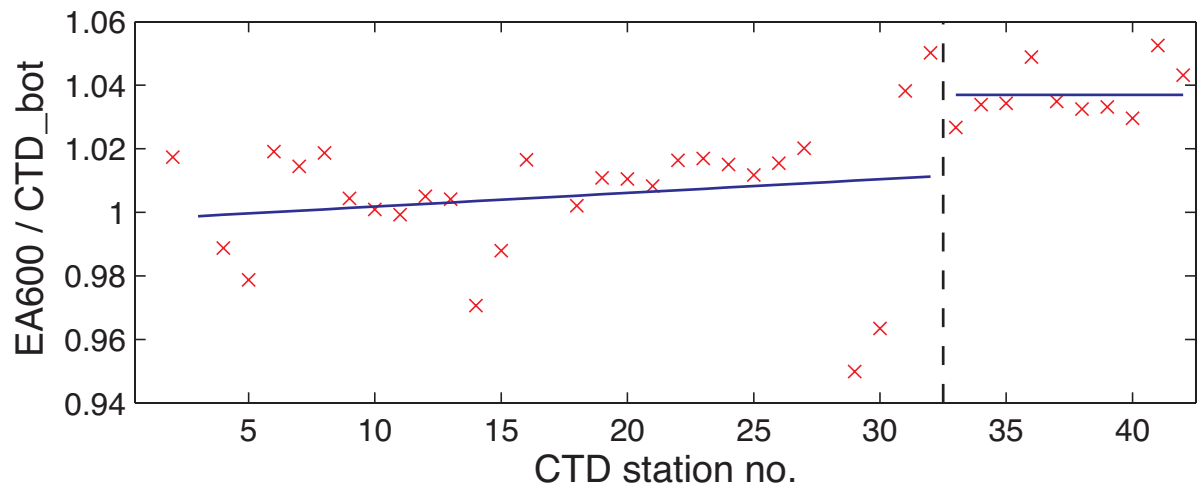


Figure 27: Ratio of depth from echo sounder to "measured depth" (actually bottom pressure plus altimeter reading). The fitted line for Drake Passage section (stations 3-32) appears to show ratio varying with location, but it is not statistically significant. For Marguerite Trough (stations 33-42), EA600 reads about 3.5% too deep.

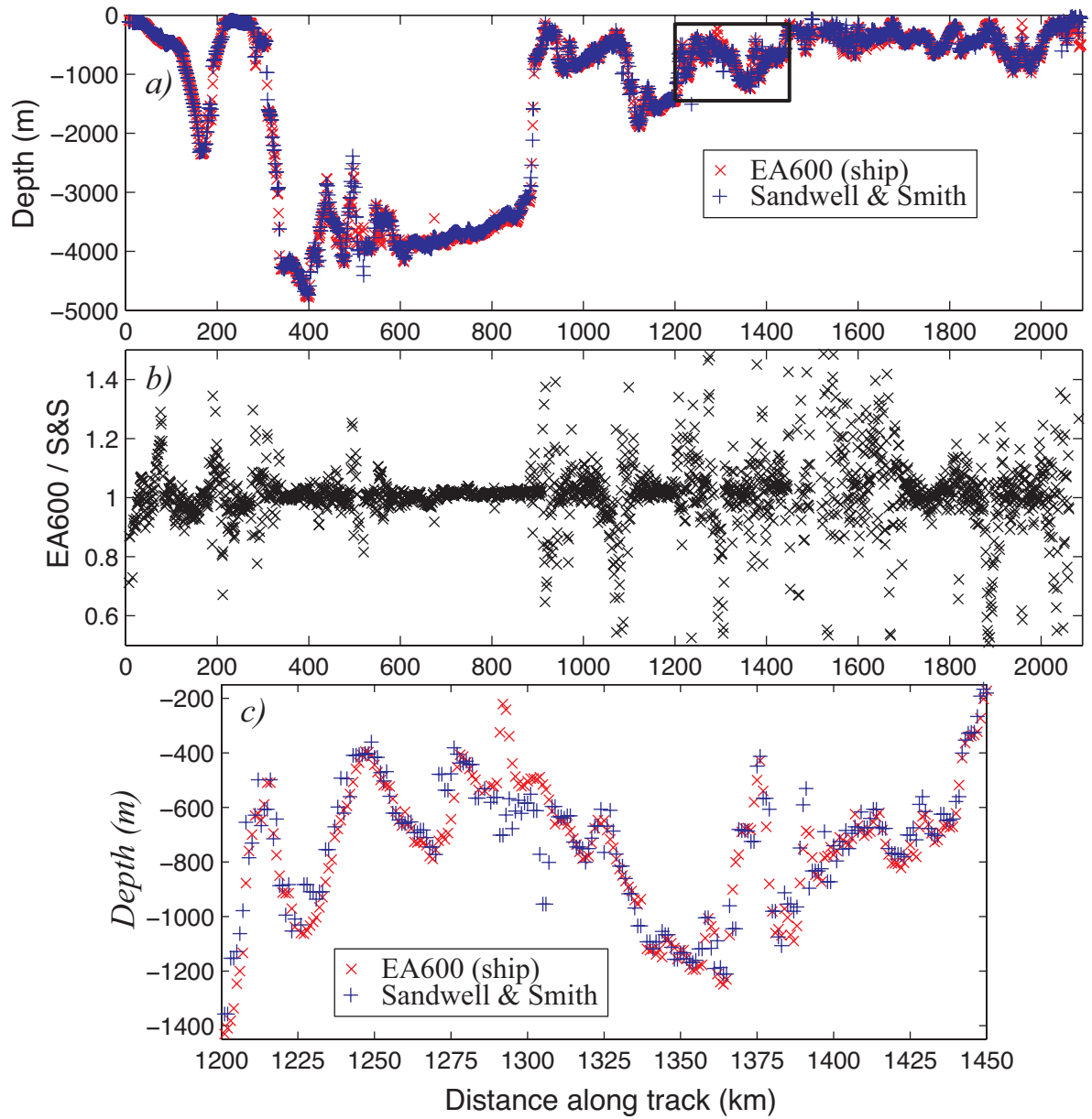


Figure 28: Plot of depth for entire duration of cruise; a) Comparison of ship echo sounder with the Sandwell & Smith (S&S) satellite-derived database; b) Ratio of the two (note there are points outside the range shown); c) Close-up on small extract from a) showing that many features are well represented in S&S, but there are significant features not present in the satellite database.

Graham Quartly

8. ARGO Float Deployment

The UK Met Office provided us with 6 ARGO floats, just in time to join the freight sent south on RRS *James Clark Ross*. These came as 2 crates of two floats, plus 2 crates of one float; five of the floats having lithium batteries, and one using alkaline. The latter was one originally ballasted for deployment in the Agulhas region, and hence was to be the first deployed on this cruise.

There were instruction sheets for initialization and deployment in each crate; these instructions were closely followed, and all deployments appeared to go satisfactorily. The process involved deployment off the aft deck of the RRS *James Clark Ross*, using a strop and crane, with a fiddle removed to release buoy once floating at the surface of the water. We noted that the deployments during the day tended to attract albatrosses, with some pecking the float. We were stationary for all deployments, allowing the current to take float away from the ship; on the last deployment it took some while for the float to be clear of the ship, so it would probably be easier if deployed with the ship moving forward, making no more than 1 knot through the water.

As this region was relatively free of ARGO floats at the time, deployment was originally scheduled for every 1° of latitude, and where depth was greater than 2000m. Whilst on the cruise, advice came through to deploy floats no further south than 58°S, else they might encounter problems with winter ice, so they were then scheduled for deployment much closer together, requiring the varying currents to disperse them. The times and locations of the deployments are given in the table below. Shortly after deployment, both the Met Office and BODC were informed.

SAMS also provided a drogued buoy for deployment somewhere in the middle of Drake Passage; this was done immediately after the 5th ARGO float; this work was overseen by the Chief Officer.

Table 5: Location and time of ARGO deployments, and the associated weather conditions.

Buoy No.	3165	3173	3172	3171	2640	2641
ARGOS ptt.	73063	73071	73070	73069	63356	63357
WMO No	1901054	1901055	1901056	1901057	1901058	1901059
Day of year / UTC	335 / 23:58	336 / 09:07	336 / 13:56	336 / 18:29	336 / 22:44	337 / 03:44
Lat (°S)	56° 03'	56° 47'	57° 06'	57° 26'	57° 44'	58° 03'
Lon (°W)	57° 37'	57° 12'	57° 01'	56° 49'	56° 38'	56° 27'
Air temperature	5.8°C	5.4°C	5.0°C	3.0°C	2.7°C	1.96°C
Sea state	4	5	2	3	4	5
Knocks or bangs?	No	No	No	No	No	No
Oil, plankton bloom or surface contamination	No	No	No	No	No	No
Remain at surface?	Yes	Yes	Yes	Yes	Yes	Yes
Comments	Pecked by albatrosses	—	Pecked by albatrosses and giant petrels	Pecked by albatrosses	—	—



Figure 29 a) The science team with our first ARGO float to be deployed; b) The crew who did the deployment.



Figure 30 a) SAMS buoy taken out of crate; b) Buoy drifting away, with drogue unfurled.

Following this cruise, we have downloaded the relevant ARGO float data from one of the real-time servers (here the US DAC at <http://www.argo.net>). In the first two months since the cruise each of the first five floats has returned 6 profiles (as would be expected for a 10-day cycle); the last float deployed has not sent any data back, and may be assumed to have failed although it passed the same checks on deployment as the others. The initial two-month journeys of the 5 successful floats are shown in Figure 31.

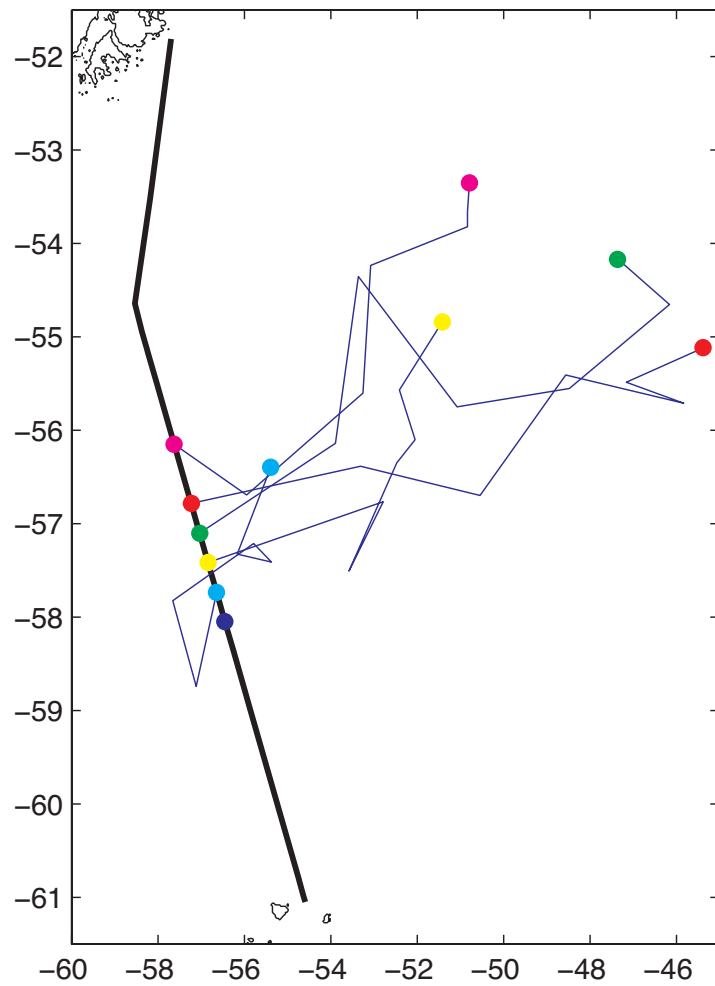


Figure 31: Trajectories of the released ARGO floats in the first 60 days since deployment. Note, the last float did not return any profiles within that period.

Graham Quartly

9. Computing Issues

There were a number of Unix workstations available, all supporting PSTAR, however the majority of the processing was run on *neptune*. Initially there were problems with the environment variables (e.g. \$CRUISE) not being properly set. These could be overcome by explicitly typing 'source ~pstar/.login', and were eventually dealt with by logging out of the system and logging in again.

A second problem related to PSTAR's graphical interface with UNIRAS. We were unable to get graphs out of PSTAR (principal requirements were for plotxy & plxyed), because the programs just crashed after the GROUTE prompt where a device is selected, with neither screen nor PostScript options working. It appeared it might be a conflict of software versions, but alternative UNIRAS setups did not help. The default setup on the Unix system used the following versions:

- pexec v5
- UNIRAS v6v5a
- workshop v4
- Matlab v14 (7.0.1)
- rvs (current = only version)

At end of cruise, we noted that the setup for rvs states a requirement for UNIRAS v6v5b, and that this occurs in some pathnames. Possibly this explains some of the problems; however, a further understanding of the problem awaits the iTss report (see section 10.3).

Incidental to the main focus of this cruise, we had acquired satellite data in NetCDF format, with the expectation that such files were readily portable and would be easily ingested into Matlab. Whilst on the cruise we found that the NetCDF toolbox was not part of the standard implementation on the ship, and a version was obtained and successfully installed, with the help of IT support.

Given that few of the scientific party were *au fait* with PSTAR, and the problems with lack of working graphical output, we strongly support the move to a new version of ship-borne computer processing, based on Matlab, possibly with NetCDF files, but retaining the version code audit provided by PSTAR. This would require NetCDF toolbox to be a fully integrated part of the Matlab available on the ship, and this would allow a range of other data to be accessed. The advantages of this approach are:

- i) better graphical displays
- ii) greater familiarity to current generation of oceanographers
- iii) ease of handling satellite datasets, which are becoming more commonly used as part of the real-time analysis during cruises.
- iv) processing could start from NMEA files, and thus remove the need for the 'rvs' processing, which is occasionally a bottleneck in the data streams.

Data were archived by making tar-files of individual data directories and then compressing with *bzip2*. Compression was quite a lengthy process (many hours). The resultant files were brought back by 2 means: several DVDs burnt using Nero on a networked PC, and a dedicated hard drive brought by Hugh Venables. The DVD method took 16 hours to write and the data were very difficult to read back at NOC; recording data to the hard disk was

essentially quick and they were easily read at NOC. Such a device should be taken on all subsequent cruises.

Graham Quartly & Hugh Venables

10. Computing Setup & Support

10.1. Personal Computers

A number of laptops were setup for use on the JCR's LAN. This included several Apple Mac's. All were setup with anti-virus and non-BAS machines had personal firewalls enabled. Laptops that didn't have anti-virus had free versions of Comodo or AVG installed and configured for auto-updates (Clam AV for the Macs).

10.2. Netware

JRUA ran without any faults and no work was required during the cruise.

10.3. Unix

Installed the latest versions of GMT and MB software.

Installed a NetCDF package for use with Matlab.

Problem discovered with the UNIRAS licence server not running. This fault has been logged with iTss and a solution has not been found as yet.

JRUB was connected to the 100MB ethernet network but should have been connected to the 1000MB ethernet network. This was fixed.

The tape library was reconnected to JRUB and some throughput tests run using a tar command to write a 60GB segment of cruise data that provided the information in Table 6.

Table 6: Data throughput rates for different connections.

Local disk to LTO3	44 MB/s
NetApp to LTO3	23MB/s
NetApp to LTO2	19MB/s
NetApp to /dev/null	27MB/s

10.4. SCS Logging system / Data logging

The SCS logging system performed reasonably well throughout the cruise, though it is starting to show its age in several areas.

The Ashtech GPS regularly (approx every 5 days) stops outputting heading information and requires power cycling.

The RVS utilities are showing a problem connecting to the data files with a message “---- Failed to attach ---“ being shown against the data stream when running *lookd* on any system other than *jrua*. This may be an indication that the RVS utilities need updating to handle current NFS protocols as this fault seems to have started following the upgrade to a network storage solution for the ship.

Table 7: Data acquisition events.

Date / Time	Event / Reason
25/11/2007 14:43	Data logging started
30/11/2007 00:08	ADU compressed datafile in the SCS became corrupted. Stopped the data logging system and replaced the Ashtec.ACO file with a blank one. Restarted the SCS data logging system.
01/12/2007 12:10	Clock drift noticed on the ADCP system. The default Windows XP NTP sync service was found to sync. once per week. K9 was installed.
05/12/2006 11:10	The Ashtech ADU5 stopped reporting the heading. This required power cycling the machine. There is a gap in the data between 07:14:39 & 11:14:53

10.5. Network

No problems reported.

Doug Willis

11. References

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Appendix 1 – JCR193 CTD Operation Instructions

Approx. 10 min before we get to the station nnn

- Create directory d:\data\jr193\jr193_nnn\
 - Open Seasave
 - check display parameters are reasonable
 - click on > realtime data > start acquisition (check that you are using jr193\jr193_final.con
 - Click on “Enter output data filename” to change output data file name and directory to directory d:\data\jr193\jr193_nnn\jr193_nnn.dat
- Turn on CTD deck unit – **red power button**
- In Seasave, click on **start acquire**
- Get logsheet and write date and name on it

On-station (whilst CTD on deck)

- Note down other information on the logsheet (i.e. lat, lon, depth, deck pressure etc.)
- Tell winch driver you are ready for deployment

CTD in the water

1. Note the time that the CTD goes into the water on the logsheet.
2. Lower to 10m and hold at this depth for 5 mins. Check that the pumps are running in the table text window.
3. Look at sensor output and check that salinity, temperature, oxygen, PAR and fluorometer look sensible and that the differences are negligible.
4. Once the pumps are on and the numbers are sensible, ask the winch driver to raise the CTD to just below the surface and lower to the bottom (tell him the expected depth).
5. When the CTD is at surface and **before it starts down**, right click on the plots and ‘erase plot’ to refresh the screen
6. Note the time that the CTD starts down from surface
7. **Watch the altimeter (number at the bottom of text window)**
8. When altimeter kicks in tell the winch driver that the CTD is 100m from the bottom, then subsequently inform him when it is at **50m from the bottom**, and then at **20m tell him there are 10m to go. Ensure the CTD STOPS 10m from bottom (15m in rough sea)**
9. At the bottom, note the time, wire-out, pressure, altimeter.
10. Go up 10m, wait 30s and **Fire Niskin Bottle No.1. Wait 10secs.** Tell the winch driver to come up to the next depth. **Watch the altimeter and check the number is increasing.**
11. At the next depth (4000m, 3000m, 2500m, 2000m, 1500m, 1000m, 700m, 400m, 200m, 100m, 10m), note down information and after 30s at depth fire the bottle, wait 10s, carry on up etc.

CTD out of the water

- Write down end lat, lon, times etc
- **Phone the bridge to inform them when we are ready to move off**
- **Stop data acquisition**

Appendix 2 – Instrument Calibration Constants

ASCII file: D:\data\jrl93\jrl93_final_second_part.con
Configuration report for SBE 911/917 plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Scans to average : 1
Surface PAR voltage added : No
NMEA position data added : No
Scan time added : No

1) Frequency, Temperature

Serial number : 2366
Calibrated on : 18/07/07
G : 4.31954507e-003
H : 6.43784825e-004
I : 2.32310210e-005
J : 2.19209612e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency, Conductivity

Serial number : 2289
Calibrated on : 17/07/07
G : -1.04139247e+001
H : 1.38985993e+000
I : -3.17526541e-003
J : 2.88945166e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency, Pressure, Digiquartz with TC

Serial number : 30856-0707
Calibrated on : 13/06/07
C1 : -4.925971e+004
C2 : -2.136250e-001
C3 : 9.435710e-003
D1 : 3.900400e-002
D2 : 0.000000e+000
T1 : 2.983458e+001
T2 : -3.883229e-004
T3 : 3.262440e-006
T4 : 3.429810e-009
T5 : 0.000000e+000
Slope : 1.00005000
Offset : -0.81450
AD590M : 1.277500e-002
AD590B : -9.391460e+000

4) Frequency, Temperature, 2

Serial number : 2307
Calibrated on : 20/07/07

G : 4.33439937e-003
 H : 6.44608874e-004
 I : 2.37793994e-005
 J : 2.31412704e-006
 F0 : 1000.000
 Slope : 1.00000000
 Offset : 0.0000

5) Frequency, Conductivity, 2

Serial number : 2222
 Calibrated on : 17/07/07
 G : -1.01969735e+001
 H : 1.42343710e+000
 I : 8.77079731e-005
 J : 8.50234811e-005
 CTcor : 3.2500e-006
 CPcor : -9.57000000e-008
 Slope : 1.00000000
 Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number : 0245
 Calibrated on : 12/06/07
 Soc : 3.8470e-001
 Boc : 0.0000
 Offset : -0.4229
 Tcor : 0.0011
 Pcor : 1.35e-004
 Tau : 0.0

7) A/D voltage 1, Free

8) A/D voltage 2, Fluorometer, Chelsea Aqua 3

Serial number : 088216
 Calibrated on : 22/06/2006
 VB : 0.523500
 V1 : 2.023400
 Vacetone : 0.560000
 Scale factor : 1.000000
 Slope : 1.000000
 Offset : 0.000000

9) A/D voltage 3, Free

- 10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor
Serial number : 7274
Calibrated on : 26/07/2007
M : 1.00000000
B : 0.00000000
Calibration constant : 56180000000.00000000
Multiplier : 1.00000000
Offset : 0.00000000
- 11) A/D voltage 5, Free
- 12) A/D voltage 6, Altimeter
Serial number : 213026993
Calibrated on :
Scale factor : 15.000
Offset : 0.000
- 13) A/D voltage 7, Free

Appendix 3 – CTD Sampling Deck Log

CTD Sampling Deck Log

RRS James Clark Ross

JR193 (Drake Passage 2007)

Station:	Time in water:
Date:	Time start down:
Julian Day:	Time at bottom:
Operator:	Wire Out (m):
Water depth (EA600):	Pressure (db):
Deck Pressure (db) Start:	Altimeter (m):
End:	Time start up:
	Time inboard:
Start Lat (°S):	End Lat (°S):
Start Lon (°W):	End Lon (°W):

Rosette Num.	Niskin Bottle Num.	Wire Out (m)	Pressure (db)	Temp (°C) & Salinity	Salts Bottle Num.	O-18 Bottle Num.	Comments
1	1						
3	2						
5	3						
7	4						
9	5						
11	6						
13	7						
15	8						
17	9						
19	10						
21	11						
23	12						

Salts sample crate number:

colour:

Sea Ice observations: